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Edited and Annotated

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1899.

PREFACE TO THE ENGLISH EDITION.

The publication of an Atlas of Urinary Sediments has, for some time, been contemplated by Messrs. Griffin. Several years ago I was approached by them with regard to this matter,* but the preparation of the contemplated work was interrupted by various uncontrollable circumstances.

On the appearance of Dr. Rieder's Atlas, Messrs. Griffin expressed the desire that I should edit for them an English edition of it. This approved itself to me, for there was no modern work of the same kind in English, and the plates were faithful and good representations of urinary sediments.

The value of the German text depends in part on Dr. Rieder's original observations and partly on the matter which he has compiled from well-known standard German treatises, such as those of Neubauer and Vogel, Salkowski and Leube, &c.

After securing the co-operation of Dr. F. C. Moore, who undertook the work of translation, I agreed to edit the English version.

A literal translation of the German text having been prepared, we revised it carefully, in order to render it as clear and concise as could be done without considerably modifying the original. I have thought it desirable, however, to shorten several passages so as to avoid needless repetitions. It would have been manifestly unfair to alter materially any of Dr. Rieder's statements, even when other opinions than those expressed by him might appear correct. When such has been the case, additions have been made in the shape of annotations for which I am responsible, these are distinguished from the original text by being enclosed within square brackets.

No bibliographical references being given in the German text, only few have been introduced in the annotations in order not to alter the style of the work. To meet this requirement the names of writers whose views have been referred to are given in each case so as to allow the reader to consult the treatises, of which a list is appended,† where he will find full bibliographical references.

We have also added an alphabetical index, which, it is hoped, will render the Atlas more useful to practical workers.

A. SHERIDAN DELÉPINE.

Manchester, *April, 1899.*

* I had then devoted much attention to the study of the changes produced in urine by disease. Thus, in the course of some eight years I had prepared notes and drawings relating to over 4,000 urinary analyses and microscopic examinations carried out entirely by myself, most of the notes and 16 out of the 20 figures which have been added to the text are derived from these records.

† See p. 100.

PREFACE TO THE GERMAN EDITION.

In the preparation of this Atlas of Urinary Sediments, which was undertaken at the request of the Publishers, I have derived considerable help from my position as assistant in the medical clinic of Geh. v. Ziemssen, who, with his usual courtesy, placed the material of the clinic at my disposal. The illustrations throughout were carefully prepared by the University draughtsman from original specimens, and the publishers have spared no expense to obtain faithful reproductions of these drawings.

All urinary sediments of any importance have, I believe, been represented, and, whilst some very rare sediments have been purposely omitted, special attention has been paid to the polymorphism of the commoner forms. The sediments have been drawn as seen with a moderately high power of a Zeiss microscope, such as may be at the command of most practitioners. With a D objective and No. 2 ocular most sediments are sufficiently magnified to allow of clear representation. In order to facilitate comparisons between the different figures and to make obvious the relative size of various constituents, the same magnification has, when possible, been employed.

In the text reference has been made to the *characters*, the mode of *occurrence*, and the *pathological significance* of urinary sediments.

With regard to the inorganic or crystalline sediments, some of the micro-chemical reactions have been given, since the crystalline form alone cannot in many cases be relied upon for diagnosis.

Dr. HERMANN RIEDER.

Munich, *November, 1897.*

Unfortunately many of the figures had to be withdrawn from their proper position and replaced by others in order to facilitate the printing in colours; this defect has been remedied as far as possible by adequate reference in the text, and by brief explanations of the individual figures arranged to face each Plate.

SYNOPTICAL TABLE OF CONTENTS.

PLATE I.

PLATE I.

FIG. 1 *and* FIG. 2. **CALCIUM CARBONATE.** Dumb-bells, crosses, and rosettes. From alkaline urine, after a *diet rich in vegetables.*

FIG. 3. Small crystals of **CALCIUM OXALATE** [imperfectly crystallised]. The majority have the form of double pyramids; irregular forms are also present [apparently derived from the oblique rhombic prism].

From a case of **OXALURIA.**

FIG. 4. **CALCIUM OXALATE.** Square prisms with pyramidal ends.

From a case of **DIABETES MELLITUS.**

FIG. 5. **CALCIUM OXALATE.** Octahedral crystals of various sizes (envelope forms); [derived from the cube or straight prism with square basis].

From a case of **CATARRHAL JAUNDICE.**

FIG. 6. **CALCIUM OXALATE.** Octahedra, envelope forms, and square prisms with pyramidal ends.

After **TYPHOID FEVER.**

PLATE II.

PLATE II.

Fig. 1. **CALCIUM CARBONATE** (colourless) and **ACID AMMONIUM URATE** (coloured); both in the form of spheroids.

From *alkaline urine.*

Fig. 2. **CALCIUM OXALATE.** Bright yellowish hour-glass-shaped crystals, with faint longitudinal striation. [Even this form of oxalate of lime, when pure, is seldom so deeply coloured as represented in the plate.]

From a case of **NEPHRITIS.**

Fig. 3. **CALCIUM OXALATE.** Oval, rounded, and other crystalline forms (dumb-bell, biscuit, hour-glass, hatchet, and spectacle forms); to the left a common octahedral form (envelope form). All the crystals are strongly refractive and (with few exceptions) have a yellowish tint. [See Fig. 2, for note regarding the colour.]

From a case of acute **CHOLERA NOSTRAS.**

Fig. 4. **CALCIUM OXALATE.** Regular and irregular faintly striated crystals; also delicate elongated six-sided plates, many of which are imbricated.

From a case of **OXALIC ACID POISONING.**

Fig. 5. **"NEUTRAL" CALCIUM PHOSPHATE.** Acicular crystals arranged in the form of rosettes, tufts, and tyrosin-like sheaves. [A very unusual form of phosphate of lime, probably impure.]

From a case of acute **RHEUMATIC ARTHRITIS** after the *administration of salicylates.*

Fig. 6. **URIC ACID.** Yellowish needles arranged in the form of large and small sheaves and rosettes. [Note the resemblance between these and crystals of urate of lime.]

From a case of **CATARRHAL JAUNDICE.**

1

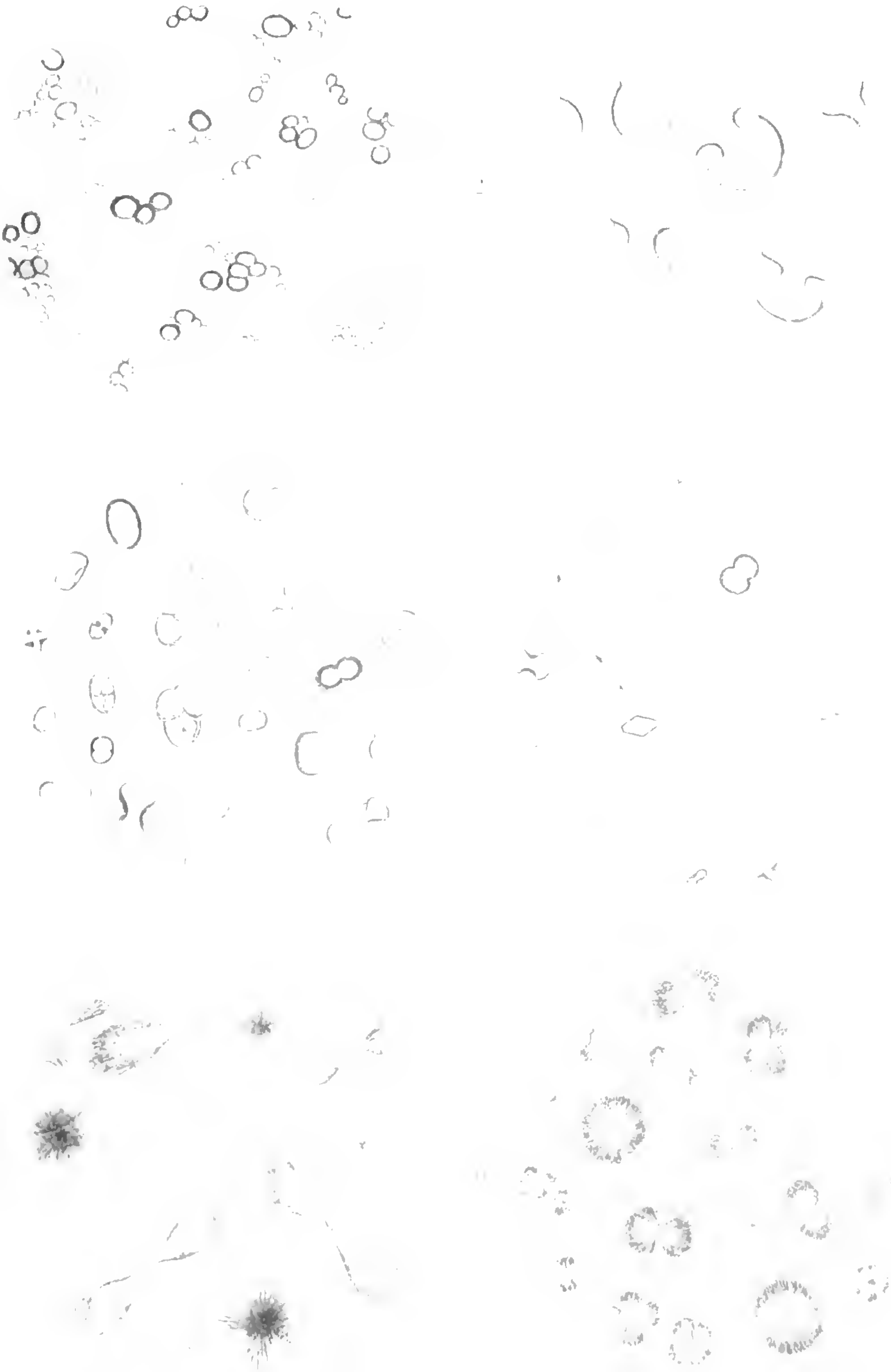

PLATE III.

PLATE III.

FIG. 1. **CALCIUM SULPHATE.** Colourless needles and plates, isolated and aggregated into rosettes.

From strongly *acid urine.*

FIG. 2. **AMORPHOUS EARTHY PHOSPHATES.** Colourless granules and spheroids of varying size.

From normal urine (more highly magnified than Fig. 3).

FIG. 3. **AMORPHOUS EARTHY PHOSPHATES.** Small colourless spheroids, some of which are aggregated into irregular clumps.

From normal urine.

FIG. 4 *and* FIG. 5. **NEUTRAL MAGNESIUM PHOSPHATE.** Large elongated plates, the majority have obliquely cut ends. Some are arranged in pairs [twin crystals], a few present eroded shagreen-like surfaces ; also acicular forms, which in some instances are attached to the original crystals.

From the alkaline (not ammoniacal) urine of a case of **CARCINOMA OF THE PYLORUS.**

(Fig. 4 is more highly magnified than Fig. 5.)

FIG. 6. **"NEUTRAL" CALCIUM PHOSPHATE [DICALCIUM PHOSPHATE].** Irregular, colourless plates and flakes, composed of granules of earthy phosphate.

From the opalescent pellicle on the surface of a light coloured, neutral urine of a case of **CHLOROSIS.**

PLATE IV.

PLATE IV.

FIG. 1. **NEUTRAL (?) CALCIUM PHOSPHATE** in the form of thin plates; **AMORPHOUS PHOSPHATES** in small colourless granules, partly free and partly adherent to the plates; and crystals of **AMMONIO-MAGNESIAN PHOSPHATE.** [The urine had been allowed to stand some time.]

From the neutral urine of a healthy person.

FIG. 2. **"NEUTRAL" CALCIUM [DICALCIUM] PHOSPHATE.** Crystalline, in the form of prisms with a pointed end, in part isolated and in part arranged in groups and rosettes [Stellar phosphate], the points of the crystals are directed towards the centres of the groups.

From slightly acid urine of a case of **RHEUMATIC ARTHRITIS.**

FIG. 3 *and* FIG. 4. **"NEUTRAL" CALCIUM [DICALCIUM] PHOSPHATE.** Crystals arranged in the form of fans, sheaves, flowers, &c.

From neutral urine of a case of **ACUTE RHEUMATIC ARTHRITIS** after the *administration of salicylates.*

FIG. 5. **AMMONIO-MAGNESIAN PHOSPHATE (TRIPLE PHOSPHATE).** Crystals arranged like intersecting fern leaves, and in irregular forms [feathery crystals].

Produced artificially by the *addition of ammonia to normal urine.*

FIG. 6. **AMMONIO-MAGNESIAN PHOSPHATE.** In feathery and shears-like crystals. [Showing the mode of grouping of twin crystals giving rise to the feathery forms.]

From alkaline urine of a case of **CYSTITIS.**

PLATE V.

PLATE V.

FIG. 1. **AMMONIO-MAGNESIAN PHOSPHATE (TRIPLE PHOSPHATE).** The common crystalline form—[*i.e.*, straight rhomboidal prism] of various sizes, with oblique terminal surfaces (coffin-lid forms). Many of the crystals deviate from the fundamental type, and a few are imperfectly developed.

From urine undergoing *ammoniacal fermentation.*

FIG. 2. **AMMONIO-MAGNESIAN PHOSPHATE.** Fern-leaf and stellate crystals. [Asymmetrical, irregular feathery forms.]

From alkaline urine of a case of **CYSTITIS.**

FIG. 3. **AMMONIO-MAGNESIAN PHOSPHATE.** Sledge forms and irregular, eroded, coffin-lid crystals. [Such appearances are often produced when the crystals undergo a slow process of solution.]

From neutral urine of a case of **CYSTITIS.**

FIG. 4. **URIC ACID.** Crystals varying in colour from greyish-violet to almost black.

After the *administration of salol.*

FIG. 5. **URIC ACID.** In the form of colourless four- and six-sided plates. [Very slightly coloured or colourless crystals of uric acid are not unfrequent in pale urines; colourless crystals present usually very simple forms. The derivation from the rhombohedron (or oblique prism with rhombic base) is generally more or less evident in these simpler forms.]

In **LEUKÆMIA.**

FIG. 6. **AMORPHOUS URATES.** Pale yellowish granules arranged in clumps and striæ (moss-like appearance).

From the "sedimentum lateritium" [pale or "nut-brown" urates] of a *febrile urine.*

PLATE VI.

PLATE VI.

FIG. 1. **URIC ACID** [impure?]. Rod like crystals arranged in sheaves.

From a very *concentrated urine.*

FIG. 2. **URIC ACID.** Dumb-bell, hour-glass, and other forms produced by partial solution.

From a strongly acid urine which had stood for some time. After a *diet rich in animal food.*

FIG. 3. **URIC ACID** [impure?] Dirty greenish-yellow, spear-shaped and rod-like crystals, partly arranged in rosettes.

From *icteric urine.*

FIG. 4. **URIC ACID.** Small crystals grouped together.

From a case in which this substance was excreted in large quantities.

FIG. 5. **URIC ACID.** Small, somewhat irregular, whetstone forms and large crosses [penetration twins] of a pale yellowish colour.

Artificially produced by the addition of acetic acid to *highly concentrated urine.*

FIG. 6. **URIC ACID.** Acicular crystals, partly isolated, partly massed together in balls. [Probably a mixture of urates, the strong resemblance with urate of lime should be noted.]

From the pultaceous crystalline contents of a *tophus.*

PLATE VII.

PLATE VII.

FIG. 1. **NEEDLES OF URIC ACID.** Irregularly scattered and arranged in tufts; also numerous granules of **AMORPHOUS URATES.** [Needles presenting appearances identical to those represented in this drawing have been found, by the editor, to give the micro-chemical reactions of urate of lime.]

From a *tophus.*

FIG. 2. **AMORPHOUS URATE GRANULES** of pale yellowish colour, aggregated in small groups. [Compare with Fig. 6, Plate V.]

FIG. 3. **ACID AMMONIUM URATE.** Small spheroids and dumb-bells.

FIG. 4. **ACID AMMONIUM URATE.** Double spheroids, the so-called dumb-bells.

From *alkaline urine.*

FIG. 5. **ACID AMMONIUM URATE.** Acicular and [imperfect] prismatic crystals arranged in the form of irregular dumb-bells and bundles. [Compare with Fig. 3, and with Plate VI., Fig 1.]

FIG. 6. **ACID AMMONIUM URATE.** Showing rhizome forms, also some **RED BLOOD-CORPUSCLES** and a crystal of **CALCIUM OXALATE.** [Acid urate of sodium may also assume this form.]

From *acid urine.*

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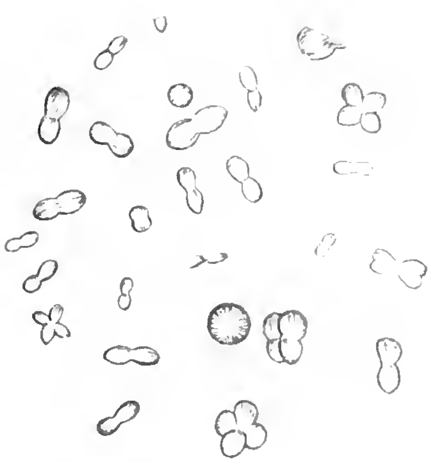


5.

6.

PLATE VIII.

PLATE VIII.

FIG. 1. **ACID AMMONIUM URATE.** Spheroidal and oval forms. [Some have radial markings due to their being composed of several small spheroids which have not been able to grow equally in all directions owing to collateral pressure.]

From *alkaline urine.*

FIG. 2. **ACID AMMONIUM URATE.** In the form of spheroids and coherent masses.

FIG. 3. **ACID AMMONIUM URATE** (spiculated spheroids), hedgehog or thorn-apple forms. [Urate of sodium may also assume this form.]

From *acid urine.*

FIG. 4. **CYSTIN.** Regular and irregular hexagonal plates of cystin; **RED AND WHITE BLOOD-CORPUSCLES**, the latter exhibiting marked changes of form resembling amœboid movement.

From a case of **CYSTINURIA.**

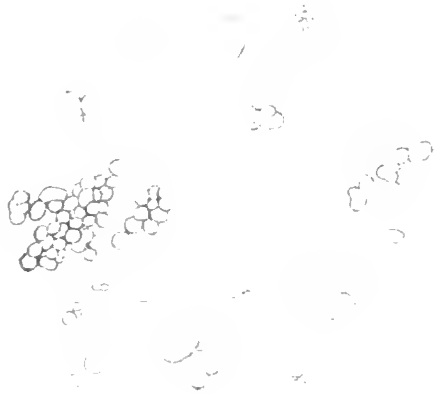
FIG. 5. **LEUCIN AND TYROSIN.** *Leucin*, in the form of spheroids, showing radial and concentric striation, small spheroids are attached to the periphery of two of the larger ones. *Tyrosin*, in the form of tufts, sheaves, and stars, showing irregular radial extension of the needles.

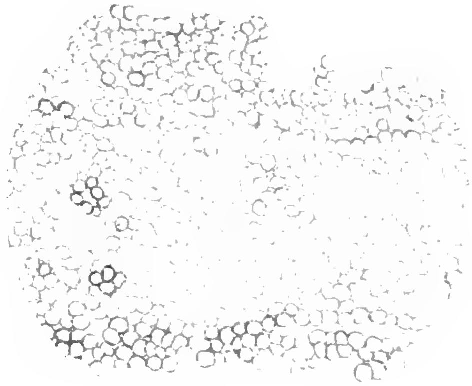
From the urinary sediment of a case of **ACUTE YELLOW ATROPHY OF THE LIVER.**

FIG. 6. **LEUCIN** spheroids.

From the urine of a case of **ACUTE YELLOW ATROPHY OF THE LIVER.**

1.





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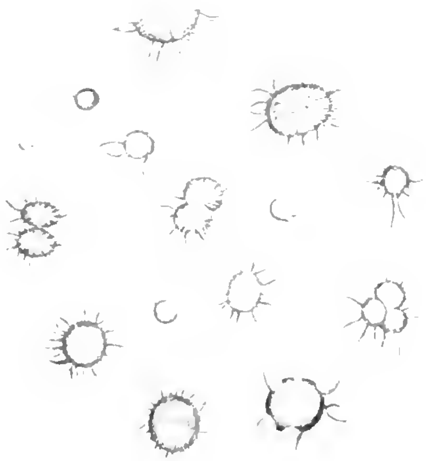

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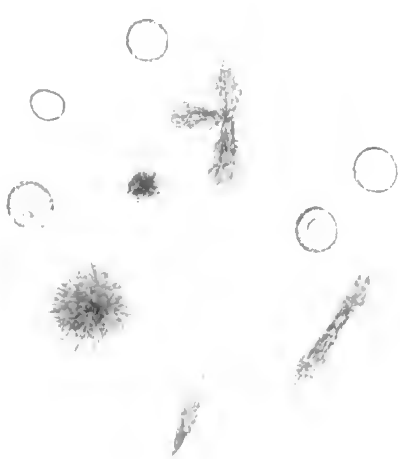

PLATE IX.

PLATE IX.

FIG. 1. **SHRED OF TISSUE** (*part of a tumour*) passed with the urine, consisting of closely packed cells (mostly epithelial) covered with acicular crystals and a few rhombic plates of *hæmatoidin.*

From a case of **CARCINOMA OF THE BLADDER.**

FIG. 2. *Naked eye appearances of some urinary sediments.*

Middle test tube—White sediment of amorphous phosphates (*i.e.*, neutral and basic **EARTHY PHOSPHATES).**

Right test tube—**PINK URATES.**

Left test tube—Pale or **CLAY-COLOURED URATES.**

FIG. 3. **URIC ACID CRYSTALS.** Whet-stone, spindle, barrel, rectangular, and quadratic forms, a few showing narrow rose-coloured bands of urinary pigments, [illustrating irregular modes of growth and pigmentation].

FIG. 4. **URIC ACID CRYSTALS** in the form of regular and irregular whetstone crystals grouped in various ways.

FIG. 5. **URIC ACID CRYSTALS** in rosettes and sunflower forms.

FIG. 6. **URIC ACID CRYSTALS.** "Drusy forms." [The word druse employed by the author is more properly applied to a cavity, the walls of which are covered with crystals projecting into the cavity. The forms represented in the picture are composed of a large number of twinned crystals radiating from an axis, and really constitute a small crystalline concretion. This remark applies also to Figs. 4 and 5.]

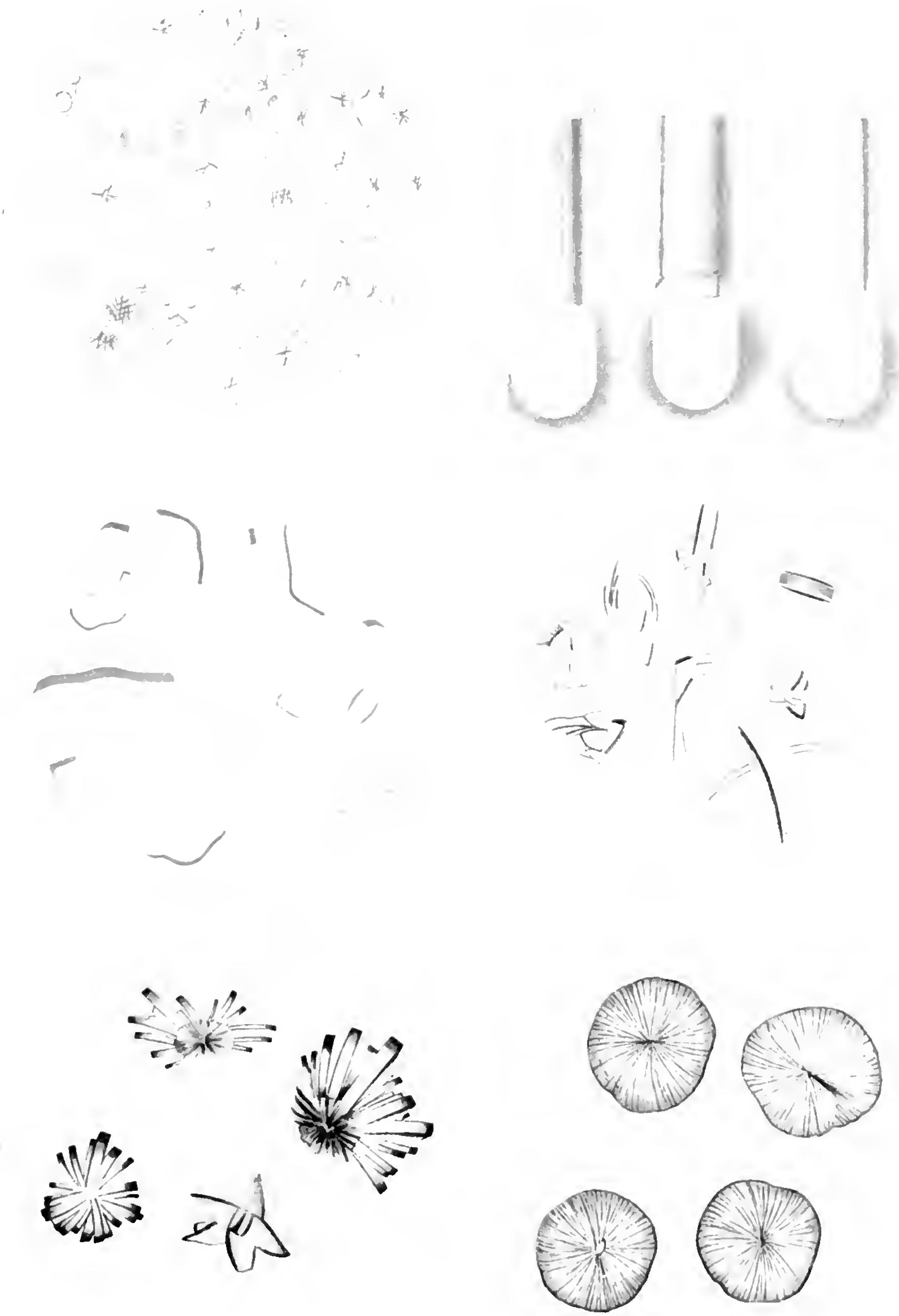

PLATE X.

PLATE X.

FIG. 1. **URIC ACID CRYSTALS.** Flask-like and spindle forms. [Showing the breaking up of large crystals into smaller crystals, an appearance which may be seen in urines undergoing alkaline fermentation. This appearance is also occasionally produced during the process of crystallisation.]

FIG. 2. **BILIRUBIN.** In the form of brownish-red needles arranged in stellate masses scattered about or in the interior of swollen and degenerated cells, which also contain variously coloured granules of biliary pigment.

FIG. 3. **BILE (ICTERIC) PIGMENTATION OF VESICAL EPITHELIUM.** Needles of bilirubin arranged in stellate masses, bile-stained crystals of **TRIPLE PHOSPHATE**, isolated and grouped in large masses.

From a case of **CATARRHAL JAUNDICE.**

FIG. 4. **BILE PIGMENTATION OF RENAL EPITHELIUM.** Bilirubin in the form of amorphous deposit and acicular crystals, partly free and partly grouped in stellate masses.

From a case of **CATARRHAL JAUNDICE.**

FIG. 5. **EPITHELIUM FROM THE MALE URETHRA.** Cylindrical epithelial cells in groups, and isolated; the free surface of almost all the cells is stained by blood pigment.

From a case of **PROSTATITIS.**

FIG. 6. **BILE PIGMENTATION OF EPITHELIUM FROM THE KIDNEY AND URINARY PASSAGES.**

From the urine of a case of **CONGENITAL SYPHILIS** with **HEPATIC LESIONS** and with **CHRONIC PARENCHYMATOUS NEPHRITIS.** (See also Fig. 4, Plate XXIV.)

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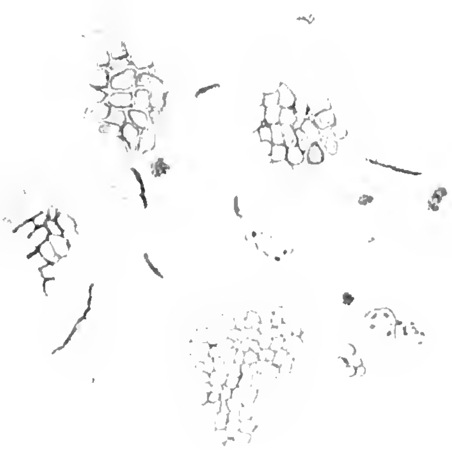

PLATE XI.

PLATE XI.

Fig. 1. **URIC ACID CRYSTALS** (Comb forms). Spontaneously precipitated. [This appearance is tolerably frequent in urines which contain large crystals of uric acid, when the reaction becomes alkaline; the crystals under those conditions become rounded, fissured, and occasionally urates become deposited round them].

From *concentrated urine after prolonged standing.*

Fig. 2. **URIC ACID.** Colourless, highly-refractive, four-, five-, and six-sided plates, also oval and rounded forms. [Crystals of triple phosphate with a shortened principal axis may be found to take this form, their nature is readily recognised by means of their chemical reactions.]

From a case of **CYSTITIS.**

Fig. 3. **URIC ACID.** Spear-shaped and lanceolate forms.

From *concentrated urine after long standing.*

Fig. 4. **URATE DEPOSIT** of rose-pink colour, above it there is a moderately thick layer of *uric acid crystals* (subsequently deposited).

Fig. 5. **CHOLESTERIN.** (Successively treated with iodine and concentrated sulphuric acid) in the form of large and small crystalline plates, presenting a variety of colours. (Crystals found in various parts of one microscopical preparation are represented as if occurring in the same microscopical field.)

Fig. 6. **URINARY INDIGO.** In the form of flakes and irregular particles, spontaneously precipitated on the occurrence of alkaline fermentation.

From a urine rich in *indican.*

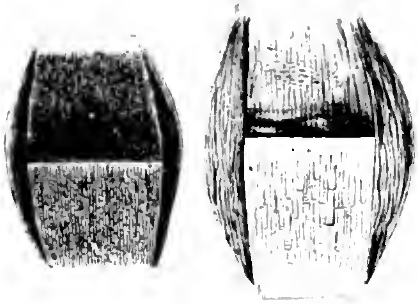

PLATE XII.

PLATE XII.

FIG. 1. **HIPPURIC ACID.** In the form of colourless rhomboid plates and prisms, isolated and in groups.

From the urine after the ingestion of a large number of "cow-berries" [*Vaccinium Vitis idæa*].

FIG. 2. **CYSTIN.** In the form of regular and irregular, thin, colourless, hexagonal plates, composed of several imbricated plates of various sizes.

From the slightly acid urine of a case of **CYSTINURIA WITH NEPHROLITHIASIS.**

FIG. 3. **CHOLESTERIN.** Rhomboid plates of various sizes, having notched angles and step-like edges.

FIG. 4. **FATTY CRYSTALS.** Curved acicular crystals, most of which are arranged in tufts and stars. [Such crystals are usually so scanty in the urine that an accurate chemical analysis is impossible; they probably contain the acid in combination with some base.]

From a case of **RENAL TUBERCULOSIS.**

FIG. 5. **NITRATE OF UREA.** In the form of free or imbricated hexagonal and rhombic plates. Artificially produced by the addition of nitric acid to *concentrated urine*.

FIG. 6. **VAGINAL EPITHELIUM.** Large, irregularly polygonal, tesselated squames with finely granular protoplasm and small oval and round nuclei, also a few, much smaller, leucocytes. (Urine obtained by means of a catheter, after washing of the vulva, contained no abnormal constituents.)

From the urine of a young girl suffering from **SIMPLE LEUCORRHŒA.**

PLATE XIII.

PLATE XIII.

FIG. 1 *and* FIG. 3. **VESICAL EPITHELIUM.** Flat, pear, or spindle shaped; also tailed and rounded cells.

Fig. 1. From a case of **CYSTITIS.**

Fig. 3. Obtained by *scraping the vesical mucous membrane.*

FIG. 2. **VESICAL EPITHELIUM** (neck of bladder). Cells of various forms and sizes; the majority are polygonal and smaller than those in Figs. 1 and 3.

FIG. 4. **EPITHELIUM FROM THE MALE URETHRA.** Cylindrical, spindle, tailed, and small round and oval cells.

Obtained by *scraping the urethral mucous membrane.* (See also Fig. 5, Pl. X.)

FIG. 5. **RENAL EPITHELIUM.** Polygonal, round, or oval cells, with fairly large oval nuclei.

Obtained by *scraping the kidney substance.*

Fig. 6. **EPITHELIUM FROM THE URETER.** Cells of various form, many provided with long processes.

Obtained by *scraping the urethral mucous membrane.*

PLATE XIV.

PLATE XIV.

FIG. 1. **EPITHELIUM FROM THE RENAL PELVIS.** Cells of various forms and sizes, many provided with one or two processes (caudate or tailed-cells), others more rounded or oval.

Obtained by *scraping the renal pelvis.*

FIG. 2. **MIXED CAST.** It contains red and white blood-corpuscles, and amorphous urate granules. A cell from the urinary passages is attached to the surface of the cast; also a group of epithelial cells.

From a case of **ACUTE HÆMORRHAGIC NEPHRITIS.**

FIG. 3. **SPERMATOZOA** isolated and in groups, two of them (in the upper part of the fig.) are immature. A few leucocytes and amorphous grauules.

From the whitish-grey floccular deposit found in a urine voided after an epileptiform seizure. **SPERMATORRHŒA.**

FIG. 4. **CYLINDROIDS.** Long, delicate, ribbon-like structures, with longitudinal striation.

From a case of **CYSTITIS.**

FIG. 5. **LEUCOCYTES (PUS-CORPUSCLES).** After treatment with acetic acid, the nuclei are very obvious.

From the acid urine of a case of **PYURIA.**

FIG. 6. **WAXY [COLLOID] CASTS.** Opaque, glistening, homogeneous, cylindrical bodies of varying breadth. The borders are sharply defined and show here and there slight indentations. [To avoid confusion the term waxy should be used only with regard to those casts which give the reaction of lardaceous or "waxy" matter.]

From a case of **LEAD POISONING** [with **CHRONIC INTERSTITIAL NEPHRITIS**] ("Contracted Kidney").

PLATE XV.

PLATE XV.

Fig. 1. **FATTY CRYSTALS AND FAT GLOBULES.** Curved needles of a yellowish colour aggregated into compact groups. In one of these groups there are a few small fat globules (See note, Fig. 4, Plate XII.)

From a case of **CHRONIC PARENCHYMATOUS NEPHRITIS** (induration stage or secondary contracted kidney).

Fig. 2. **FIBRIN.** Long strands made up of threads of fibrin, between these a number of delicate fibrin threads are irregularly distribnted. Also a few **FAT GLOBULES** and **RED** and **WHITE BLOOD-CORPUSCLES,** the latter being stained with hæmoglobin.

From a case of **HÆMATURIA.**

Fig. 3. **URETHRAL THREAD** (low power), a piece of one. A delicate yellowish-white structure consisting of cells imbedded in mucus.

From a case of **GONORRHŒAL URETHRITIS.**

Fig. 4. **ERYTHROCYTES** (red blood-corpuscles). Some retaining their normal colour, others pale, having had their hæmoglobin dissolved out; they vary in form and size, some are round and biconcave, others crenated; also a few microcytes.

From acid urine in a case of **HÆMATURIA.**

Fig. 5. (*a*) **BILE-STAINED HYALINE CAST,** convoluted, of a faint yellow colour.

(*b*) **BACTERIA** aggregated together in the form of a cast.

From a case of **ICTERUS,** *the urine had been exposed to the air for a long time.*

Fig. 6. **GRANULAR CASTS.** Somewhat dark, finely granular bodies, one of which shows indentations and clear spaces; at one place a degenerated epithelial cell is imbedded in the cast.

PLATE XVI.

PLATE XVI.

On the left.
FIG. 1. (a) **LEUCOCYTE CAST** [or purulent cast]. A hyaline cast thickly coated* with leucocytes [or pus-corpuscles].

From a case of **RENAL ABSCESS.**

In the middle.
(b) **BLOOD CAST.** A hyaline cast thickly coated* with red blood-corpuscles.

From a case of **ACUTE HÆMORRHAGIC NEPHRITIS.**

On the right.
(c) **FATTY CAST.** A cast thickly coated* with large and small fat globules.

From a case of **SECONDARY CONTRACTED† KIDNEY.**

FIG. 2. **EPITHELIAL CASTS.** Hyaline casts containing a large number of blood-stained renal epithelial cells.

From a case of **LARGE WHITE KIDNEY.**

FIG. 3. **AMMONIUM URATE CASTS.** The crystalline, spheroidal masses are aggregated into cast-like bodies of a dark olive-green colour.

From a case of **URATIC INFILTRATION (OR INFARCT) OF THE KIDNEY** *in a new-born child.*

FIG. 4. **PSEUDO CASTS.**

Below.
(α) Small fragment of **DICALCIUM PHOSPHATE** from a urine in which this salt had separated in the form of scales.

From *Icteric Urine.*

Above.
(β) Small **URIC ACID CRYSTALS** arranged in the form of a cast.

From *Concentrated Urine.*

FIG. 5 *and* FIG. 6. **A LOBULATED VASCULAR PAPILLA** (Villus) covered with epithelium. Fresh and unstained. Fig. 5 more highly magnified than Fig. 6 [semi-diagrammatic].

From a case of **VILLOUS TUMOUR OF THE BLADDER.**

* [The author describes casts as being *covered* with leucocytes, red blood-corpuscles, fat globules, &c.; in a large proportion of cases, however, many of these elements are found also imbedded in the hyaline substance of the cast.]

† Regarding nomenclature see text (p. 94).

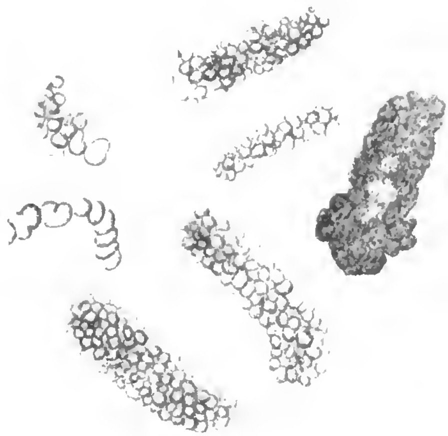

PLATE XVII.

PLATE XVII.

FIG. 1. **PHENYL GLUCOSAZON.** Yellowish-green acicular crystals grouped in tufts, sheaves, and rosettes.

Obtained by the application of the phenyl-hydrazin test to **DIABETIC URINE.**

FIG. 2. **FIBRIN.** In the form of a network. Spontaneously deposited. Shown on a black background (natural size).

From a case of **FIBRINURIA.**

FIG. 3. **URETHRAL THREAD.** A piece of one highly magnified. Many leucocytes and a few scattered epithelial cells from the urinary passages imbedded in a mucous matrix. (See also Plate XV., Fig. 3.)

FIG. 4. **HYALINE CASTS.** One of which contains leucocytes, amorphous granules, and acicular crystals (fatty?).

FIG. 5. **A WAXY [COLLOID] CAST** (convoluted) and a **GRANULAR CAST.** [See annotation, Plate XIV., Fig. 6.]

FIG. 6. **A FRAGMENT OF TISSUE** found in the urine. Hardened in alcohol and stained with hæmotoxylin and eosin [semi-diagrammatic.]

VILLOUS TUMOUR OF THE BLADDER. (See also Plate XVI., Figs. 5 and 6.)

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PLATE XVIII.

PLATE XVIII.

FIG. 1. **INDIGO.** In the form of irregular, rhombic, light and dark blue crystals, isolated and in groups. Crystallised by dissolving amorphous, spontaneously deposited, urinary indigo in chloroform and allowing the *solution* to evaporate slowly.

FIG. 2. **INDIGO.** In the form of delicate, curved, dark blue needles, the majority grouped in tufts and stars. Crystallised by dissolving amorphous, spontaneously deposited, indigo in chloroform and evaporating the solution rapidly.

FIG. 3. **SPERMATOZOA.** Showing the pyriform head, the intermediate piece, and the thin flagellum-like tail. In those stained with methylene blue the head piece is seen to contain a spheroidal structure sharply defined.

From a case of **SPERMATORRHŒA.**

FIG. 4. **URETHRAL THREAD.** A piece of one stained with methylene blue and highly magnified. Pus-corpuscles and epithelial cells imbedded in a mucous matrix, the nuclei, as well as the intra- and extra-cellular gonococci, are very deeply stained.

From a case of **GONORRHŒAL URETHRITIS.**

FIG. 5. **MICROCOCCUS UREÆ.** A non-pathogenic microbe. From the pellicle formed on the surface of an *ammoniacal urine.* On the right, unstained; on the left, stained with gentian violet.

FIG. 6. **TUBERCLE BACILLI.** Large groups of tubercle bacilli, stained red. Other bacteria and pus-corpuscles, stained blue. Stained with carbol-fuchsin and methylene blue according to the *Ziehl-Neelsen method.*

From the fresh urine of a case of **RENAL TUBERCULOSIS.**

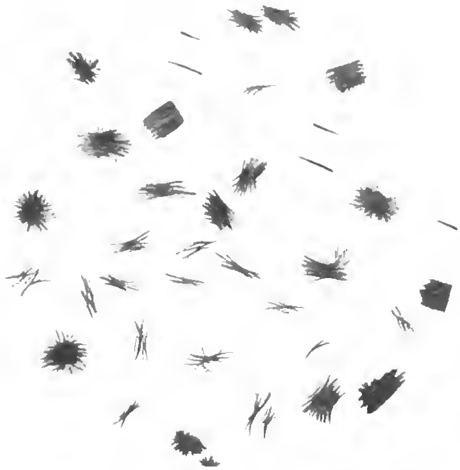

PLATE XIX.

PLATE XIX.

FIG. 1. **TUBERCLE BACILLI.** Stained red, the majority are slightly curved. They are frequently lying across one another, and aggregated into small and large groups. The other bacteria and the nuclei of the pus-corpusles are stained blue. Stained with carbol-fuchsin and methylene blue, according to the *Ziehl-Neelsen method.*

From the alkaline urine of a case of **CHRONIC RENAL TUBERCULOSIS.**

FIG. 2. **GONOCOCCI.** Partly extra- and partly intra-cellular. The characteristic form of the pairs is clearly shown. Two hemispheres opposed by their flattened slightly concave surfaces.

From the centrifugalised urine of a case of **ACUTE GONORRHŒA.**

FIG. 3. **LARGE BACILLI** (frequently found in decomposing urine). Stained with methylene blue.

From a case of **CYSTITIS.**

FIG. 4. **STAPHYLOCOCCI** in large and small groups. Stained with methylene blue.

Obtained by centrifugalisation from freshly voided urine of a case of **"IDIOPATHIC" BACTERIURIA** (so-called).

FIG. 5. **BLOOD PIGMENT.** In the form of irregular brown flakes of various sizes, also leucocytes and epithelial cells, almost all of which are squamous.

From the urine after *menstruation.*

FIG. 6. **SQUAMOUS EPITHELIUM, ERYTHROCYTES,** decolourised (in the centre), **LEUCOCYTES,** and **COLLOID** casts of varying size and form, some of these are beset with large granules, others with leucocytes. Sediment stained with methyl-violet, none of the colloid casts show the characteristic rose-red colouration characteristic of lardaceous (amyloid) matter.

Chronic **PARENCHYMATOUS NEPHRITIS** (large mottled kidney). See also Plate XXX., Fig. 1, and Plate XXXI. from the same case.

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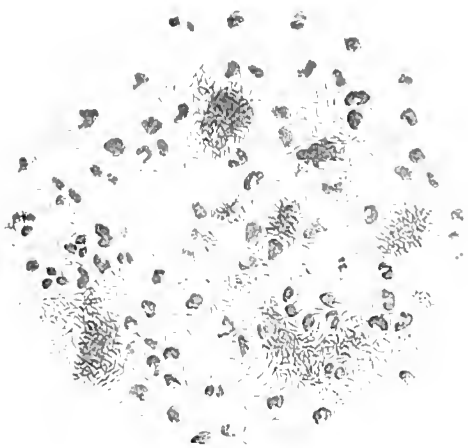

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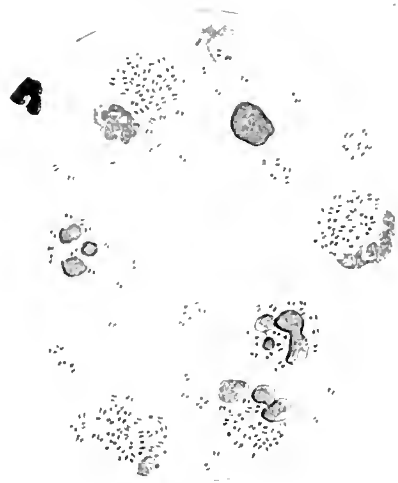

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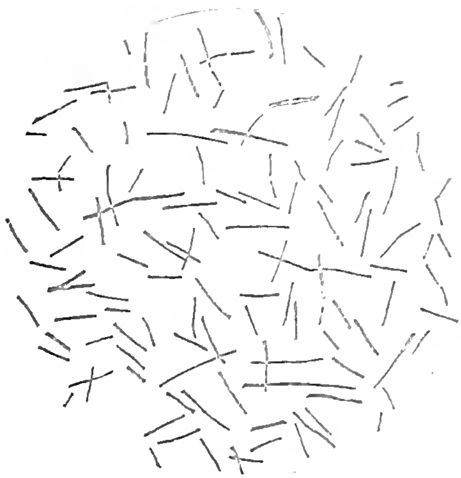

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PLATE XX.

PLATE XX.

Fig. 1. **EPITHELIAL CASTS** in the form of **EPITHELIAL TUBES** composed of epithelial lining of the renal tubules.

From a case of **SCARLATINAL NEPHRITIS.**

Fig. 2. **BACTERIUM (BACILLUS) UREÆ.** A non-pathogenic microbe (short rods).

From the pellicle on the surface of an *ammoniacal urine.*

Fig. 3. **YEAST (SACCHAROMYCES).** Oval cells about the size of leucocytes, united in chains, or isolated. Here and there small daughter cells are seen growing from the larger mother cells (budding).

From *diabetic urine.*

Fig. 4. **MOULD (PENICILLIUM GLAUCUM).** Mycelium and conidia.

From fermenting *diabetic urine.*

Fig. 5. **MOULD,** forming mycelium.

From normal urine which had stood for a considerable time.

Fig. 6. **MOULD** (probably oïdium).

From the dense white pellicle on the surface of a *diabetic urine* which had been exposed to the air for a long time.

PLATE XXI.

PLATE XXI.

FIG. 1. **SARCINÆ** in large and small bale-like packets.

FIG. 2. **STREPTOCOCCI AND BACILLUS COLI COMMUNIS** (identified by cultivation), also white and red **BLOOD-CORPUSCLES, EPITHELIAL** and **HYALINE CASTS,** partly colloid.

From the urine of a case of **SCARLATINA NEPHRITIS.**

FIG. 3. **GERMINATING MOULD SPORES** coloured brown by urates.

From *diabetic urine.*

FIG. 4. Flakes of **DICALCIUM PHOSPHATE.** Four and six-sided colourless crystals of **URIC ACID, EPITHELIUM,** budding fungi, and segmented hypha of a mould.

Urine of *a new-born child.*

FIG. 5. **YEAST CELLS** (Saccharomyces). Crystals of **URIC ACID** (barrel and whet-stone forms) and **CALCIUM OXALATE** (envelope forms).

Urine in *acid fermentation.*

FIG. 6. Yellow spheroids of **AMMONIUM URATE.** Coffin lid crystals of **AMMONIO-MAGNESIAN PHOSPHATE** and **AMORPHOUS CALCIUM PHOSPHATE.**

Urine in *alkaline fermentation.*

PLATE XXII.

PLATE XXII.

FIG. 1. Small dumb-bells and amorphous masses of **CALCIUM CARBONATE,** large crystals of **AMMONIO-MAGNESIAN PHOSPHATE.**

Alkaline fermentation of the urine.

FIG. 2. Yellowish needles and rods of **ACID AMMONIUM URATE,** isolated and arranged in irregular stars: also two crystals of **TRIPLE PHOSPHATE.**

Alkaline fermentation of the urine.

FIG. 3. **SWOLLEN VESICAL EPITHELIUM,** granular dèbris, and **AMMONIO-MAGNESIAN PHOSPHATE** crystals of various sizes. Urine of alkaline reaction.

From a case of **CHRONIC CYSTITIS.**

FIG. 4. **LEUCOCYTES** (pus-corpuscles) in various phases of degeneration, many swollen; isolated **EPITHELIAL CELLS,** crystals of **TRIPLE PHOSPHATE.** Urine of alkaline reaction.

From a case of **CHRONIC CYSTITIS.**

FIG. 5. **HYALINE CASTS, EPITHELIAL CELLS** from the kidney and from the urinary passages, and **LEUCOCYTES.**

From a case of **CARDIAC DISEASE**—(*Cardiac kidney, engorged kidney*).

FIG. 6. Coarsely **GRANULAR CASTS.** Fairly thick crystals of **URIC ACID,** isolated and in groups.

From a case of **LEAD POISONING** (*chronic interstitial nephritis, contracted kidney*).

PLATE XXIII.

PLATE XXIII.

FIG. 1. **RED BLOOD-CORPUSCLES**, decolourised (laked); **WHITE BLOOD-CORPUSCLES**, blood-stained. Various forms of **EPITHELIAL CELLS** from the urinary passages, with nuclei blood-stained.

From a case of **SUBACUTE CYSTITIS.**

FIG. 2. **WHITE AND RED BLOOD-CORPUSCLES.** The latter numerous, varying in size and form. Their hæmoglobin well retained. In many corpuscles a characteristic umbilication is noticeable [which indicates the original biconcave shape of the corpuscle exaggerated by the bulging of the marginal zone. This bulging is the result of the swelling produced by endosmosis; in some corpuscles the umbilication has entirely disappeared on one side].

From a case of **RENAL HÆMATURIA.**

FIG. 3. Club-shaped, spear-head, and whet-stone crystals of **URIC ACID; EPITHELIUM** (so-called tailed cells), **LEUCOCYTES, RED BLOOD-CORPUSCLES** (decolourised, but recognisable by their double contour).

From a case of **CALCULOUS PYELITIS.**

FIG. 4. Blood-stained **RENAL EPITHELIUM** forming cylindrical masses, **SQUAMOUS CELLS, LEUCOCYTES, HYALINE,** and **GRANULAR CASTS,** numerous large bacilli.

From a case of **ACUTE NEPHRITIS.**

FIG. 5. **HYALINE CASTS.** Containing urate granules and blood stained **LEUCOCYTES** (leucocyte casts); crystals of **CALCIUM OXALATE,** mostly of the oval and hour-glass forms: **EPITHELIAL CELLS.**

From a case of **ACUTE GASTRO-ENTERITIS** with **NEPHRITIS.**

FIG. 6. Thick **GRANULAR CASTS.** In part blood-stained; **LEUCOCYTE CASTS,** also blood-stained: **HYALINE CASTS; EPITHELIAL CELLS,** mostly from the bladder; the nuclei of the vesical cells are blood-stained: many **LEUCOCYTES.**

From a case of **PUERPERAL SEPTICÆMIA,** with **SUB-ACUTE NEPHRITIS.**

PLATE XXIV.

PLATE XXIV.

FIG. 1. **STREPTOCOCCI AND BACILLUS COLI COMMUNIS (?).** The former in long chains, the latter in groups of slightly curved thin rods. Also numerous **LEUCOCYTES** and **ERYTHROCYTES.** Stained with carbol-fuchsin. The nature of the bacillus was ascertained by cultivation.

From a case of **SCARLATINAL NEPHRITIS.**

FIG. 2. Slender **HYALINE CASTS, RENAL AND VESICAL EPITHELIAL CELLS,** the latter showing the characteristic pointed processes which pass from their deep aspect among subjacent cells.

From a case of **NEPHRITIS.**

FIG. 3. Bile-stained **GRANULAR CASTS** from icteric urine.

From the same case as Fig. 4.

FIG. 4. **BILE-STAINED GRANULAR CASTS.** Rod-like crystals of **URIC ACID** [impure] disposed in rosettes. The bile-stained renal epithelium has been represented in Plate X., Fig. 6.

HEPATIC SYPHILIS with **CHRONIC PARENCHYMATOUS NEPHRITIS.**

FIG. 5. **AIR BUBBLES** often observed in preparations of urinary sediments. Spherical forms, with dark outlines showing the effects of focussing at various levels. Irregular, flattened bubbles occurring in preparations which have become partly dry.

FIG. 6. **MYCELIAL FILAMENTS.** From the white pellicle formed on the surface of urine which had stood for a long time exposed to the air.

PLATE XXV.

PLATE XXV.

FIG. 1. **HYALINE, GRANULAR, EPITHELIAL, AND LEUCOCYTE CASTS.** The majority coloured yellowish-green (in various degrees) by hæmoglobin; epithelium, especially **RENAL EPITHELIUM** in small groups, and numerous **LEUCOCYTES** scattered and enclosed in hyaline casts.

From a case of **ACUTE NEPHRITIS** occurring in a child aged eight years, affected with **SCARLET FEVER** (recovery).

FIG. 2. **RED BLOOD-CORPUSCLES,** the majority well-formed but decolourised, many broken down; **AMORPHOUS URATE** granules in great abundance; numerous **LEUCOCYTES,** free and aggregated into groups, stained yellow with hæmoglobin; and **CASTS** (also stained with hæmoglobin) containing urate granules and leucocytes.

ACUTE HÆMORRHAGIC NEPHRITIS occurring in a case of **CROUPOUS PNEUMONIA** (recovery).

1.

PLATE XXVI.

PLATE XXVI.

Fig. 1. Numerous **HYALINE CASTS** (of various sizes), straight and convoluted; in some of them leucocytes and epithelial cells are imbedded forming; **LEUCOCYTE** and **EPITHELIAL CASTS**; in the lower part of the figure there are a **FATTY CAST** and a **GRANULAR CAST**; *leucocytes*, isolated and in groups; a few *epithelial cells*; **URIC ACID** crystals of various forms, the barrel form predominating; also four- and six-sided plates, the larger crystals being yellow, the smaller colourless.

ACUTE NEPHRITIS (ætiology unknown, recovery).

Fig. 2. **BLOOD, LEUCOCYTE, AND MIXED CASTS.** *Epithelium* mostly from the urinary passages; *red blood-corpuscles* of various size and form, in part decolourised; *leucocytes* (with nuclei stained yellow with hæmoglobin); **URIC ACID** crystals.

ACUTE HÆMORRHAGIC NEPHRITIS (ætiology unknown, recovery).

PLATE XXVII.

PLATE XXVII.

FIG. 1. **HYALINE CASTS,** of various length and thickness, covered with urate granules; below and to the left of the figure a **CYLINDROID** appears attached to a large epithelial cell; numerous isolated **URATE GRANULES;** whetstone and barrel-shaped crystals of **URIC ACID;** **EPITHELIAL CELLS** and **LEUCOCYTES,** some of which are free, others contained within casts.

ACUTE TOXIC NEPHRITIS in **TETANUS** (with fatal termination).

FIG. 2. **HYALINE CASTS** (of various sizes). Most of them contain a few albuminous granules, in one case fatty epithelium; one **FATTY CAST** is also visible in the lower part of the figure. There are also *renal* **EPITHELIAL CELLS** and **LEUCOCYTES,** most of them fatty **(GRANULE CELLS); FREE ALBUMINOUS GRANULES** (epithelial débris); isolated **LEUCOCYTES,** and decolourised red *blood-corpuscles.*

SUBACUTE NEPHRITIS (large white kidney), terminating fatally.

PLATE XXVIII.

PLATE XXVIII.

FIG. 1. **BLOOD, LEUCOCYTE, AND HYALINE CASTS,** some of which are colourless whilst others are stained brown by blood pigment. Many free *leucocytes*, some stained yellowish-brown by blood pigment; also **URIC ACID** crystals and **SQUAMOUS EPITHELIUM.**

HÆMORRHAGIC INFARCTION of the kidney.

FIG. 2. **BILE-STAINED EPITHELIUM, LEUCOCYTES, AND CASTS,** some **GRANULAR,** others containing epithelial cells; **CYLINDROIDS; FATTY NEEDLES** (colourless); crystals of **CALCIUM OXALATE;** needles of **BILIRUBIN,** some free and arranged in stars, others deposited within or on the surface of cells; amorphous bilirubin in the form of small granules contained within cells.

ICTERUS GRAVIS with **NEPHRITIS** (recovery).

PLATE XXIX.

PLATE XXIX.

FIG. 1. **URIC ACID,** club-shaped and spear-shaped crystals, many grouped together, or deposited on other crystals covering them with numerous pointed processes.

From the strongly acid urine of a case of **CALCULOUS PYELITIS.**

FIG. 2. Isolated **FAT GRANULE CELLS** (epithelial cells and leucocytes). Some stained with blood pigment; **RENAL EPITHELIUM** partly intact, partly fatty; **CASTS** containing albuminous granules, fat-drops, and fat-granule cells.

SUBACUTE NEPHRITIS terminating fatally (large white kidney).

PLATE XXX.

PLATE XXX.

FIG. 1. **GRANULAR CASTS** containing red blood-corpusles, albuminous and fatty granules; **EPITHELIAL CELLS** from the kidneys and urinary passages, most of which are arranged in groups, many of the cells are swollen and in a condition of fatty degeneration; free albuminous granules and numerous free **RED BLOOD-CORPUSCLES.**

CHRONIC HÆMORRHAGIC NEPHRITIS (large red kidney) terminating fatally (the same case as in Plate XXXI.)

FIG. 2. **HYALINE, [COLLOID], BLOOD,** and **LEUCOCYTE CASTS; EPITHELIUM** (chiefly from the kidney), in part fatty; leucocytes, red blood-corpuscles, epithelial débris and broken up blood-corpuscles.

CHRONIC HÆMORRHAGIC NEPHRITIS (large red kidney) terminating fatally.

PLATE XXXI.

PLATE XXXI.

Finely and coarsely **GRANULAR CASTS**; many **COLLOID CASTS** convoluted and straight, showing cracks and tears, most of these casts are very long and thick, a few of them contain albuminous granules, leucocytes, and epithelial cells. Also free swollen **RENAL EPITHELIAL CELLS,** a few stained yellow by hæmoglobin; **LEUCOCYTES** and isolated **RED BLOOD-CORPUSCLES.**

CHRONIC HÆMORRHAGIC NEPHRITIS (large red kidney) terminating fatally. The same case as in Fig. 1, Plate XXX., at a later stage, when severe uræmic attacks had supervened.

[In Plate XIX. the same sediment is represented after being stained with methyl-violet, to show that the casts did not give the lardaceous reaction.]

PLATE XXXII.

PLATE XXXII.

FIG. 1. **HYALINE, GRANULAR, EPITHELIAL,** and **BLOOD CASTS; CYLINDROID; RENAL EPITHELIUM** and **LEUCOCYTES,** partly free, partly contained in casts; also a few free albuminous granules.

SECONDARY CONTRACTED KIDNEY* (small mottled kidney) terminating fatally.

FIG. 2. **CASTS** with numerous **ALBUMINOUS GRANULES,** and, in consequence, having a dusty appearance; **FATTY CASTS; FAT GRANULE CELLS,** partly free, partly contained in casts; innumerable scattered albuminous granules.

CHRONIC INTERSTITIAL NEPHRITIS (SECONDARY CONTRACTED KIDNEY*) terminating fatally.

* For meaning of nomenclature see p. 94.

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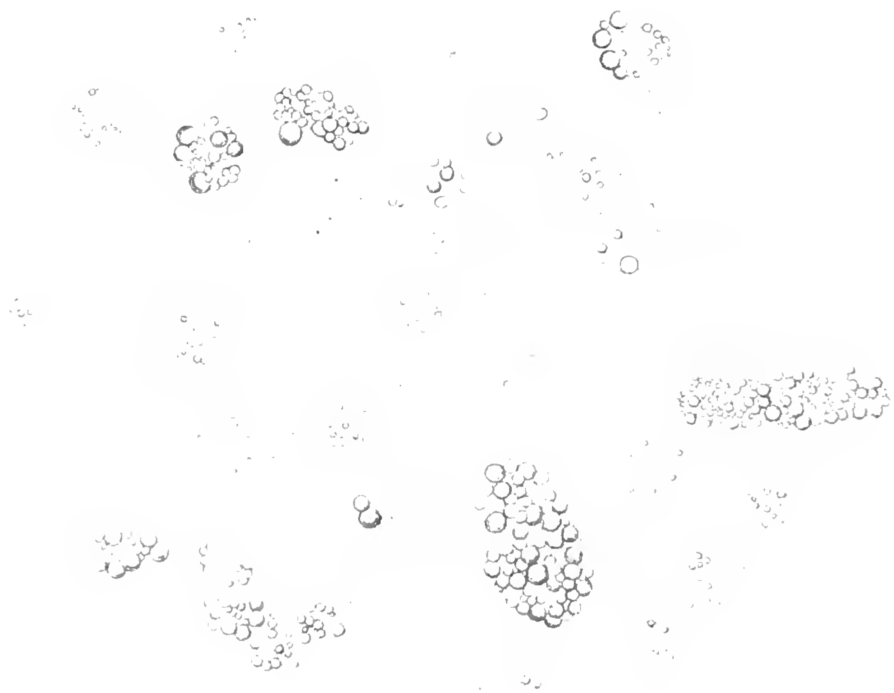

PLATE XXXIII.

PLATE XXXIII.

Fig. 1. **FAT GLOBULES.** After treatment with osmic acid.

Fig. 2. **FAT GLOBULES** stained with "*Sudan III.*"* **HYALINE** and **GRANULAR CASTS,** in some of which there are large and small fat globules and fat granule cells. Also free **FAT GRANULE CELLS.** The fat globules are stained bright red.

SECONDARY CONTRACTED KIDNEY. The same case as in Fig. 2, Plate XXXII.

* See note in the text (p. 45).

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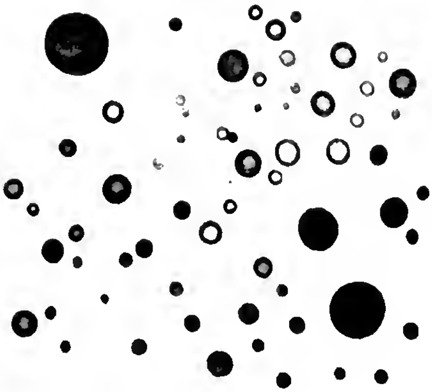

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PLATE XXXIV.

PLATE XXXIV.

HYALINE CASTS, thick and slender, straight and convoluted. Finely and coarsely **GRANULAR CASTS**; **EPITHELIAL CASTS**; **EPITHELIAL CELLS** from the kidneys and urinary passages; isolated **LEUCOCYTES** and amorphous granules.

CHRONIC INTERSTITIAL NEPHRITIS (Arterio-sclerotic contracted kidney).

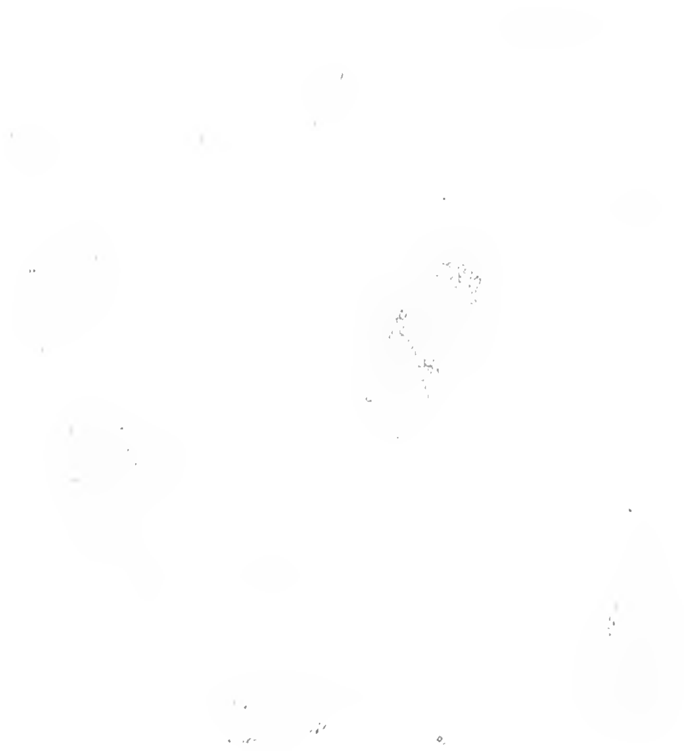

PLATE XXXV.

PLATE XXXV.

Fig. 1. **CONVOLUTED, BILE-STAINED, CAST.**

CAST containing **FAT GRANULE CELLS.** Stained with osmic acid.

Fig. 2. **PSEUDO CAST** composed of swollen, **BILE-STAINED, EPITHELIAL CELLS** forming a cylindrical mass.

TRUE, BILE-STAINED, EPITHELIAL CASTS.

Fig. 3. **CONTAMINATIONS OF URINARY SEDIMENTS.**

Feather barbs, in the upper part of the figure (low and high magnification); fragments of *pubic hair*, to the left; to the right of these are some *starch grains* (wheat) from dusting powder (highly magnified). In the right-hand lower corner of the figure there are some *fat globules* of various sizes (highly magnified).

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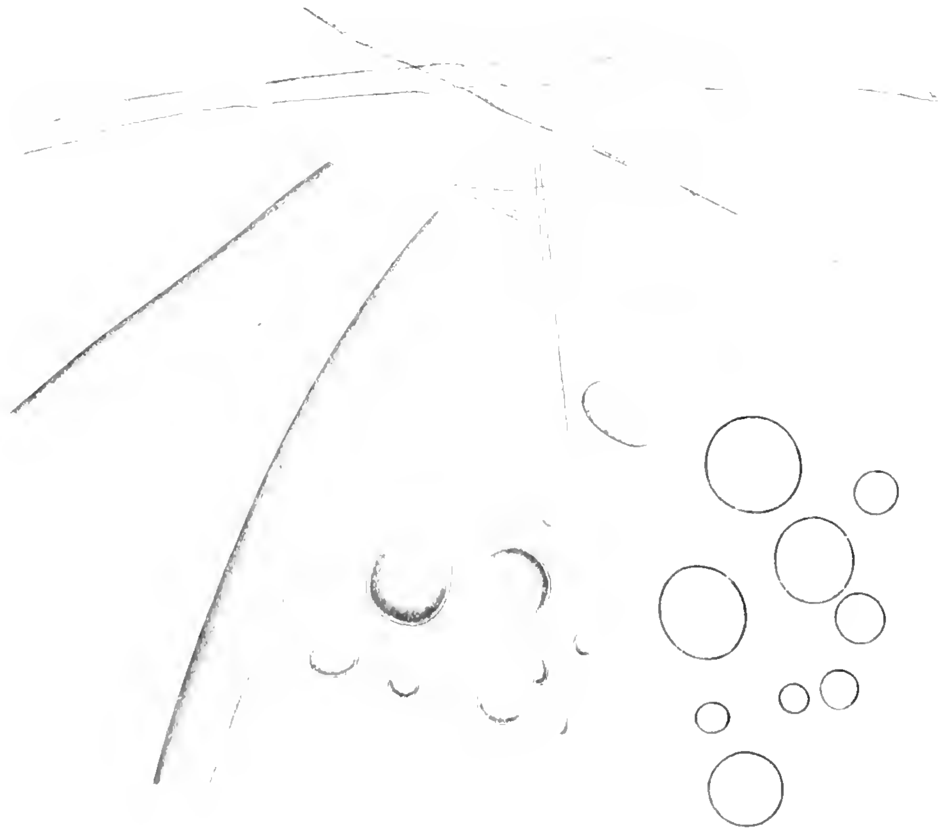


PLATE XXXVI.

PLATE XXXVI.

FIG. 1. **HYALINE, LEUCOCYTE, AND BLOOD CASTS; FREE LEUCOCYTES,** many of which are blood-stained; **EPITHELIAL CELLS, RED BLOOD-CORPUSCLES** isolated and in groups; curved colourless fatty needles.

From a case of **CHRONIC RENAL TUBERCULOSIS.**

FIG. 2. **CONTAMINATIONS OF URINARY SEDIMENTS.** In the upper part of the figure and from left to right, the following objects are represented—*cotton wool. wool* (dyed and undyed), *silk;* in the lower part, *flax threads* (new and washed). All the objects are represented under low and high magnification.

AN ATLAS

OF

URINARY SEDIMENTS.

INTRODUCTION.

The Urine may be regarded as an excretion which removes from the body those ultimate products of metabolism which have passed into the blood stream.

It is essentially a dilute watery solution of certain inorganic and organic salts which are produced by various combinations of the following bases and acids:—potassium, sodium, ammonium, calcium, and magnesium; urea, creatinin, and the xanthin bases; hydrochloric, sulphuric, phosphoric, and carbonic acids; uric, oxalic, hippuric, and some other acids belonging to the aromatic series. In addition, mucin, certain pigments, and ferments are also present.

In disease several other substances occur in the urine and, even in health, minute quantities of some organic and inorganic bodies, not mentioned here, are found.

In interpreting the results of a microscopical examination, it should always be borne in mind that the urine not infrequently contains products derived from the male and female genital organs and, occasionally, from the alimentary canal and skin.

URINARY SEDIMENTS.

When urine is allowed to stand, certain of its constituents are deposited, sometimes very rapidly, at other times slowly. This work deals almost exclusively with the microscopical characters of these sediments.*

Cloudy Deposit.—In every urine which has stood for some time a cloudy deposit (**Nubecula** of older writers) appears, consisting of mucus, together with a few leucocytes and epithelial cells from the urinary passages.

* [It is well to remember that it is often desirable to examine the urine immediately after it has been voided and before any sediment has had time to form in the usual manner.]

[The following products may also be found in this cloudy deposit; bacteria, amorphous phosphates, small phosphatic crystals, scales produced by the breaking up of the thin pellicle (usually composed chiefly of earthy phosphates) which forms on the surface of certain urines, and minute crystals of oxalate of lime. The nubecula is essentially a bulky flocculent precipitate of mucin, composed of transparent filaments or shreds forming a kind of clot. This (at first very bulky, very light and almost invisible) gradually shrinks, carrying down with it all the light elements suspended in the urine. This soft network is easily broken up; nevertheless it shows evidence of a slight degree of cohesion. Light precipitates, which separate from the urine after the cloudy deposit has formed (*e.g.*, urates, and small crystals of oxalate of lime) may remain suspended on its surface, which then presents a more opaque appearance than the deeper parts. Though this cloudy deposit occurs in most urines, it is very much more marked in some cases than in others.]

Since **decomposition** of the urine leads to alteration and often disintegration of the organised constituents, it is important that urine collected for examination should be received in clean or, if possible, sterilised vessels, which ought to be immediately covered, so as to prevent the dust and bacteria floating in the air from contaminating the fluid during the subsidence of the sediment.

Sedimentation Glasses.—For sedimentation, long conical glasses are generally used; the urinary deposit forms, at the bottom of such vessels, a layer readily appreciable to the unaided eye.

[Instead of the long conical glass in general use it is better to use a cylindrical glass. Test tubes about 6 to 8 inches in length, $\frac{3}{4}$ inch in diameter, kept vertical by means of a suitable foot or stand, answer the purpose very well.

In conical vessels it is often difficult to keep the narrow recess at the apex of the cone perfectly clean. To obtain crystalline sediments, which have accumulated in the same narrow space, it is necessary to use pipettes drawn to a fine point and even with such a pipette it is difficult to avoid crushing some of the larger bodies which have accumulated in the recess. The formation of strata, by the successive deposition of elements of various specific gravity, is much more regular in cylindrical than in conical vessels, so that it is easier to compare the relative amounts of the various constituents of a sediment in a cylindrical than in a conical vessel.]

The Pipette.—As a rule a quantity of sediment sufficient for examination will be found at the bottom of the glass after a few hours standing; this deposit may be removed for further examination by means of a glass pipette, as follows:—The point of the pipette is dipped into the sediment, the upper end being completely closed by the finger. Then, by slightly raising the latter, a sufficient quantity of sediment is allowed to enter the tube which is again well closed so as to prevent the clear supernatant fluid from following the sediment. The pipette is withdrawn and the fluid allowed to drop from the point by cautiously raising the finger, until

the sediment itself appears, when a drop is placed on a slide and covered with a coverglass.

[In taking samples of a sediment by means of a pipette, one should always bear in mind that some morbid products are very brittle (*e.g.*, some of the tube casts composed of blood-corpuscles or of epithelial cells). If one wishes to obtain these intact, it is necessary to prevent any sudden rush of fluid through the narrow opening of the pipette. It will, therefore, be found advisable to proceed as follows:—The sediment having subsided, the fluid above it is carefully decanted, or syphoned off, to within about 1 inch of the surface of the deposit. This should be done without disturbing the deposit. By removing the unnecessary column of fluid, one diminishes the pressure forcing the urine and sediment into the pipette.

The pipette itself should be a narrow tube about $\frac{1}{8}$ inch in diameter ending in a blunt cone, having a terminal orifice measuring not less than $\frac{1}{50}$ inch in diameter. It should be 2 or 3 inches longer than the sedimentation tube. This makes it easy to hold the pipette between the thumb and middle finger and to close its upper end with the index finger. The upper opening of the pipette should be kept quite dry, and its edge should be evenly cut and well rounded, so that perfect closure may be obtained by pressing the index finger lightly against it. If all these details be attended to, it is quite easy to collect any part of the sediment by lifting slightly the index finger, after the point of the pipette has been brought *just above* the part of the deposit which one wants to examine, and closing again the upper end of the pipette as soon as a few drops of fluid have been allowed to run into it.

Microscopical Preparation.—A microscopical preparation of the sediment is obtained as follows:—The pipette being held in a vertical position, is brought over a slide so that the point nearly touches the part where the sediment has to be deposited; as soon as the drop at the end of the pipette comes in contact with the glass, a small amount of fluid passes on to the slide, and then by relaxing for an instant the pressure of the index finger closing the upper end of the pipette, as much fluid as is thought desirable is allowed to run out. *This amount of fluid should be just large enough to occupy the space between the cover-glass and the slide;* if too large a drop be used the lighter objects, such as small hyaline tube casts, may be driven beyond the edge of the cover glass by the current produced by the pressure of the cover.

It will be found advantageous in practice to use large round coverglasses 1 inch or $1\frac{1}{4}$ inches in diameter (this, of course, necessitates proportionately large slides). Large drops of sediment may then be examined with a comparatively low power ($\times$ 50 to $\times$ 100) in a short time; any suspicious object may afterwards be more thoroughly studied under the high power.

The Light.—Great care should be paid to the lighting of the specimens, the more transparent elements, such as hyaline tube casts, shreds of mucus, small colourless crystals, bacteria, are almost invisible when the whole of the light reflected by the concave mirror is allowed to fall upon the object; it is prac-

tically impossible to see them when an Abbe's condenser is used without diaphragm. When a concave mirror or a condenser is employed it is necessary to reduce the cone of light by means of a substage diaphragm. When strong, even, diffuse light, such as may be obtained from a white cloud, is available, the flat mirror may be used with advantage.]

Since the various constituents of the sediment by virtue of their different specific gravities, subside more or less rapidly, the examination of different strata of the sediment is in some cases very instructive.

Accidental Disappearance of Tube Casts.—The microscopical examination of the urine, as a rule, should be made as soon as possible after its evacuation, so as to avoid alterations in the sediment, and particularly in the urinary casts. It has been suggested that these may be completely disintegrated and dissolved by the pepsin contained in the urine.

[It is, however, open to question whether the small amount of pepsin which has been demonstrated in the urine can be supposed to account for the disappearance of tube casts. It must be remembered that, in the test for pepsin, the fibrin, which has been allowed to remain in urine, is not digested till it has been removed from that fluid and placed in dilute hydrochloric acid.

The disappearance of tube casts is generally associated, either with bacterial fermentation, or with the shaking of the fluid. Cellular tube casts are easily broken into small, often unrecognisable fragments, by careless handling of specimens. When a sample of urine has to be carried about before examination, the bottle containing it should be completely filled, and violent agitation of the fluid carefully avoided.]

Preservatives.—The addition of certain substances chemically indifferent (powdered camphor, chloroform, oil of peppermint, thymol, and specially formol up to about 0·5 per cent.) increases the stability of the urine and of its formed constituents, this precaution is particularly indicated in summer time when decomposition of the urine by putrefactive bacteria occurs rapidly.

[**Refrigeration.**—It is preferable to prevent the decomposition of the urine by keeping it at a low temperature (below 4° C.) than by the addition of any chemical substance. This can easily be done by placing the specimens in a small refrigerator or in any other contrivance acting in the same way.]

Immediate Examination of the Urine.—The sediment is rarely so abundant as to render the urine uniformly turbid, but when such is the case a drop of urine may be examined microscopically at once, without waiting for sedimentation.

Filtration.—When the immediate examination of the formed constituents is desirable, the urine may be passed through a paper filter, and when all but a few drops has passed through, a drop of what remains in the filter is transferred to a slide for examination. [The sediment may also be separated by means of small porous earth filters.]

Centrifugalisation.—Sedimentation may be accelerated by the use of the

centrifugal machine; by this method it is possible to obtain from a small quantity of urine, in a few minutes, enough sediment for microscopical examination.

[It is better, whenever possible, to obtain the sediment by centrifugalisation *as soon as possible after the urine has been evacuated.* There are now many forms of centrifugal machines (or centrifuges as they are often called) which are inexpensive and well adapted to clinical work. Among these may be mentioned, as being the simplest, the one devised by Gaertner, and which is represented in Fig. 1.]

[1. A shallow circular tray provided with a lid which can be screwed tightly into its place. The bottom of the tray slopes downwards from the centre to the periphery. By means of suitable springs, metal tubes may be fixed to this sloping bottom. These tubes or metal case are arranged radially, and are equidistant. Strong test tubes, after being filled and corked are placed in these cases with their mouths directed towards the centre of the tray.

2. Vertical axis to which the circular tray (1) is firmly fixed.

This axis is made to spin rapidly by coiling round it a strong cord (3), and, when the cord is completely coiled, pulling it quickly by means of the handle. This causes the axis and tray fixed to it to spin (top like), sufficiently long and rapidly to cause a partial separation of the sediment. If the separation is not complete enough after a first spinning, the process may be repeated. Similar machines may be obtained which are worked by water or steam turbines, or by electric motors.]

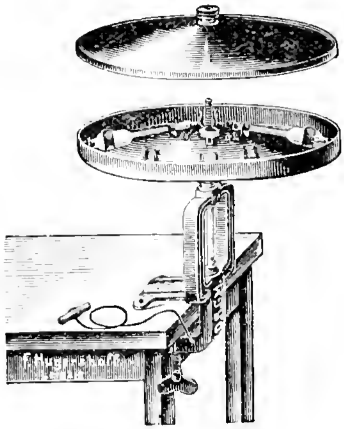


Fig. 1.—Centrifuge or Separator (*Gaertner*).

Macroscopic Characters of Sediments.—In many cases the nature of a sediment may be surmised from its macroscopic appearances; as, for instance, the purulent sediment in cystitis, the white phosphatic sediment, the brick-dust sediment (lateritious sediment), consisting of urates or of urates mixed with crystals of uric acid, the granular or sandy sediment of uric acid, which is often spoken of as **urinary sand** or **gravel** when the crystals form large masses.

[By slightly inclining the vessel containing a sample of urine, or by giving to it a slight rotatory motion, it is generally possible to obtain useful information regarding the nature of the sediment.

Some sediments are very light, so that the slightest motion of the fluid will cause them to rise in the shape of an uneven cloud in the fluid above them; in such cases the sediment may be described as light and diffusible.

In other cases, the sediment, though light, is not so easily broken up, owing to its parts being held together by a network of fibrinous or mucous shreds. Sometimes the sediment is gelatinous looking and adheres to the side of the

vessel, so that, notwithstanding its evident lightness, it is difficult to displace it; such a sediment may be described as light and adhesive.

Other deposits are composed of heavy coarse particles, which are not easily displaced by slight motions of the fluid.

Whether heavy or light, sediments may be crystalline or not. This is easily recognised when the particles composing the deposit are large; when they are very small, their crystalline character may often be made out by the appearance which they present when light is allowed to fall obliquely on the urine, specially when this is held against a dark background. The slightest motion will then cause the crystals to move, and their facets will reflect beams of light which give to the sediment a sparkling appearance. In addition to this, thin pellicles and crystalline plates may be iridescent.

Very small transparent bodies of uniform size, such as bacteria, cause, when the fluid is disturbed, a play of light which is quite characteristic and may be compared to that produced by watered silk.

By taking these various features and the colour into consideration, it is often possible to determine the nature of a sediment or of its various parts by a simple naked eye examination. This information, which is obtained in a few seconds, should only be used as a guide, and must not be thought to be as reliable as the knowledge gained by a careful microscopical examination.

The following are the naked eye characters of some of the more common sediments:—

A. Light Diffusible Sediments.

1. *Cloudy, Translucent or Semi-transparent, Non-crystalline.*

   Bacteria, spermatozoa, tube casts, cells from urinary passages, and scanty precipitates of mucin.

2. *Cloudy, Translucent, Crystalline.*

   Small oxalate of lime crystals, small colourless crystals of uric acid, phosphatic scales (iridescent), small crystals of phosphate of lime (heavier and more opaque than the other sediments in this group).

3. *Whitish, Non-crystalline.*

   Pus in acid urine (as in some cases of pyelonephritis and renal abscess).

   Amorphous phosphates (heavier than the last).

   Vaginal cells in large quantities.

   Starch (an extraneous product sometimes found in quantities large enough to produce a distinct deposit).

4. *Pale Buff-yellow, Brownish-yellow, Pink.*

   Amorphous urates.

5. *Smoky, Brownish-red or Bright Red.*

   Blood from the kidney, or oozing slowly from the urinary passages or bladder (in acid urine).

B. Light, Non-diffusible (or Slightly Diffusible).

6. *Non-adhesive, Whitish, Cloudy, Flocculent* (easily broken up). Common cloudy deposit (nubecula).

When urates or oxalates become precipitated after this deposit has formed, the surface of the cloud becomes more opaque than the rest. Crystals of oxalate of lime in certain lights give to the flocculent surface a shiny, silvery appearance (silvery cloud).

7. *Adhesive or Non-adhesive, Dark or Bright-red Clots.*

Blood, usually resulting from abundant hæmorrhage from the bladder or urinary passages. When the urine becomes alkaline, blood clots become darker in colour and adhesive.

8. *Very Adhesive, Translucent, Jelly-like,* with whitish or yellowish opaque streaks or patches.

So-called muco-pus, associated with chronic cystitis, when the urine has become ammoniacal.

The surface of such sediments is often covered with a thick layer of urates, and large crystals of ammonio-magnesian phosphate may also form a layer at the bottom or be suspended in the midst of the sediment.

C. **Heavy Sediments (Generally Crystalline).**

9. *Transparent, Colourless, Crystalline.*

Large crystals of triple phosphate, the prismatic shape of the crystals may often be recognised with the naked eye. Large crystals of oxalate of lime may occasionally produce a sediment of this type.

10. *Whitish, Crystalline.*

Phosphate of lime (opaque white).

Oxalate of lime (translucent white).

11. *Ochre Yellow or Reddish-brown, Non-crystalline.*

Urate of sodium or ammonium (spherules)—(often associated with 10 and 12).

12. *Pale Yellow, Reddish-brown, Orange, Brick Red, Crystalline.*

Uric acid.

This list does not include those products which, like fat globules, are of lower specific gravity than the urine, or which crystallise in thin plates, and remain suspended, in the form of a pellicle, on the surface of the fluid. Among the products which may form films on the surface of the urine may be mentioned fat globules, leucin, cholesterin plates, small crystals of cystin, phosphates, carbonates, indigo, &c.

Sediments are seldom composed of one product only, so that some of the types given above are often modified by admixture. Sediments forming slowly are often stratified, each stratum presenting features of its own.]

Micro-chemical Reactions.—Reliable information as to the nature of a sediment can be obtained only by a combination of microscopical and chemical examination; the latter ought never to be omitted in cases where the results of microscopic examination are at all doubtful.

The chemical reactions of a sediment may be tested microscopically as well as macroscopically. In the former case, the slide with the sediment is placed under

the microscope, and some of the reagent allowed to flow under the edge of the coverglass, this being aided by placing a small strip of filter paper against the opposite edge of the coverglass.

In the same way a crystalline sediment may be washed and its chemical reactions then tested more accurately.

It must be distinctly remembered in applying micro-chemical tests, that crystalline sediments often require a long time (several minutes) for solution, and also that the artificial separation of crystals under the coverglass for diagnostic purposes is often considerably protracted.

[A simple method may be used to follow under the microscope the action *of a reagent*. A small drop of urine, or of water holding in suspension the *washed precipitate*, is placed on a slide; another small drop of the reagent is deposited quite near the first drop, actual contact being avoided. The two drops must be equal as nearly as possible, and, together, must contain just enough fluid to fill the space under the coverglass. The coverglass is then allowed to fall gently and evenly on the two drops at the same time. This is easily done and the result is a preparation in which nearly one half of the coverglass is over the reagent, and the greater part of the other half covers the fluid to be tested; in a zone running along one of the diameters of the coverglass the two fluids are mixed. Now, it is evident that on one side of this zone the reagent is in excess, whilst on the other side it is the fluid to be tested which predominates. In this way the effects of various proportions of the reagent may be observed very rapidly. The two fluids continue to mix by a slow process of diffusion, beyond the zone of contact, and this allows the gradual action of minimal quantities of reagent to be observed at leisure.

Another very convenient method may also be adopted. After the drop of fluid has been deposited on the slide, a cotton or silk thread is placed across it in such a way that after the drop has been covered the thread will run straight through the preparation and project on both sides of the coverglass. A drop of reagent is then deposited at one end of the thread. The reagent gradually passes under the coverglass owing to the effects of capillarity. The current may be regulated by removing more or less fluid from under the coverglass by placing a small triangle of filter paper in contact with the other end of the thread.

Colour reactions, precipitation, evolution of gases, crystallisation, solution, &c., may be observed with advantage in these ways. It is, of course, necessary to examine such preparations under the microscope without the slightest delay.

It is essential to use reagents in a suitable *state of dilution*. Strong acids or alkalies are seldom wanted. On the other hand, the reagents must not be used in such dilutions that when added to the urine they contain enough water to keep in solution the precipitates which are looked for.

Thus, if sulphuric acid be added to a sediment containing urate of lime, and the total amount of sulphuric acid added is less than one part to, say, five

hundred parts of water, a precipitate of uric acid will slowly appear, but the sulphate of lime will remain in solution instead of forming typical crystals. It is, therefore, necessary to know the solubility of the precipitates which one wishes to obtain for diagnostic purposes, and use such proportions of the reagents as will make their crystallisation or precipitation possible. There are cases, however, when the total quantity of material available for examination is so small that it is not possible to obtain a precipitate at all.

All micro-chemical reactions should be observed under the microscope from the beginning. It is, therefore, well to carry out all the manipulations on the stage of the microscope, a low power being used to watch the early stages of the reaction. The high power can be used afterwards to complete the observation.

In current micro-chemical work, it is always advisable to try the solubility of precipitates in organic acids first, and to use mineral acids afterwards. In this way carbonates, phosphates, oxalates, sulphates, and urates, may readily be differentiated. As reagents, the most generally useful acids are acetic acid, hydrochloric acid, and sulphuric acid.

It is well, when dealing with urinary sediments, always to remember that their characters are often modified by the presence of various soluble salts and organic products in the medium from which they are precipitated.]

Classification of Sediments.—In a urinary sediment we distinguish *organised* constituents, that is, the cells and their products; and *unorganised* constituents, which may be crystalline or non-crystalline. The latter may, with few exceptions, occur in the urine of perfectly healthy individuals. The former, when abundant, generally indicate the existence of disease, and more specially of lesions of the kidney and urinary passages; certain cells are, however, invariably present in small numbers, even in healthy urines.

[It would, perhaps, be more accurate to say, that there are few unorganised sediments which may not be found in healthy urines, and that it is more their quantity than their actual presence which, in certain cases, indicates disease. With regard to the organised products, on the contrary, many, by their presence alone, indicate the existence of definite morbid changes (more especially in connection with the genito-urinary organs). Their study is, therefore, of the highest importance for purposes of diagnosis.]

It should be made a rule to test the reaction of the urine before proceeding to the microscopical examination, since this affords useful indications regarding the nature of certain deposits.

Sediments of sodium urate, uric acid, calcium oxalate, leucin, and tyrosin, occur usually in acid urines, whilst others, such as most phosphates, calcium carbonate, ammonium urate, occur generally in neutral or alkaline urines.

The following analytical synopsis of the principal unorganised urinary sediments is taken from Sahli:—

Readily soluble on heating, .	*Urates.**	
Not soluble on heating.		
Soluble in acetic acid, .	*Phosphates.*	Without evolution of gas.
	Carbonates.	With evolution of carbonic acid gas.
	Ammonium urate.	After 10 to 15 minutes* separation of uric acid.
Not soluble in acetic acid,	*Calcium Oxalate.*	Soluble in hydrochloric acid.
	Leucin, Tyrosin, Xanthin, Cystin. Uric acid.	Insoluble in hydrochloric acid.

* [Normal *urate of lime* is very slightly soluble in boiling water, and slowly acted upon by acetic acid. Spherules having the characters of *acid urate of ammonium* sometimes resist for a considerable time the action of hot water and of acetic acid. It is probable that many of the uratic precipitates which present abnormal features, notably with regard to solubility, are not simple urates of the alkaline metals. The earthy urates are much less soluble than the alkaline urates. Normal urate of lime can easily be distinguished from acid urate of ammonium, not only by its appearance, but also by the action of dilute sulphuric acid.]

I. UNORGANISED SEDIMENTS.

Carbonate of Lime. Calcium Carbonate.

Plates I., II., and XXII.

Although of very frequent occurrence in the urine of herbivora, crystalline or amorphous precipitates of carbonate of lime are rarely recognised in human urine. This product is generally deposited along with phosphates (calcium phosphate) from alkaline urine which has stood for some time, and particularly after the ingestion of large quantities of vegetable food. It may occur in a crystalline form, in the shape of small granules, or in granular masses; the two forms may be deposited simultaneously. In exceptional cases carbonate of lime has been found in slightly acid urine along with crystals of calcium oxalate. It may also enter into the composition of the opalescent film which occasionally forms on the surface of alkaline urine, where it is generally associated with triple phosphate and acid ammonium urate (Plate II., Fig. 1; Plate XXII., Fig. 1). From the latter the largest calcium carbonate spheroids cannot always be readily distinguished by simple microscopical examination.

Calcium carbonate crystallises in colourless, faintly glistening, concentrically striated spheroids, which are generally much smaller than those of acid ammonium urate.

The spheroids, which frequently present deep indentations, the result of irregular crystallisation, occur almost invariably in pairs, forming the so-called dumb bells, drumstick or biscuit forms, which may be grouped so as to form crosses, rosettes, or comparatively large nodular masses.

On the addition of a drop of any mineral acid the sediment rapidly dissolves with effervescence due to the evolution of carbon dioxide.

Before applying this test the sediment should be well washed with water to free it from soluble carbonates, more specially ammonium carbonate (which also effervesces on the addition of an acid).

[Carbonate of calcium does not often crystallise in the urine under the form of typical rhombohedra. *Siegmund* says that indications of this mode of crystallisation are not infrequently seen, but this is barely in accordance with common experience. When a dilute solution of an alkaline carbonate, say carbonate of sodium, is added to a soluble salt of calcium, such as chloride of calcium, typical rhombohedra are present in large numbers in the precipitate. The

presence of soluble salts of many other metals does not interfere with this crystallisation, but magnesium salts and various organic products may prevent the formation of typical rhombohedra.

Rainey has shown that the presence of viscid organic matter—*e.g.*, certain albuminoid substances—prevents the formation of sharply defined crystals and induces that of spheroids.

It is possible to recognise under the microscope that the spheroids of carbonate of calcium found in urine are composed of prismatic crystals or needles, held together by a matrix of some transparent organic substance which may also hold some pigment.

Beale has demonstrated the presence of this matrix by slowly dissolving the carbonate of calcium with acetic acid.

When there is an abundant precipitate of salts of lime in the urine it is easy to demonstrate the nature of the base by means of dilute sulphuric acid. The solution of the product is followed by a precipitation of prisms of sulphate of lime which are comparatively insoluble (see p. 8).

Or, after washing the precipitate and dissolving it, the presence of lime may be demonstrated by adding to the preparation a weak solution of oxalate of ammonium, when typical crystals of oxalate of lime will rapidly appear.]

Further differential points will be mentioned in the section dealing with acid ammonium urate.

Oxalate of Lime. Calcium Oxalate.

(Plates I., II., XXVIII., &c.)

Under ordinary circumstances calcium oxalate is held in solution in the urine by acid phosphate of sodium, and, as a rule, does not separate out, either in health or disease, until the urine has stood for some considerable time—*i.e.*, not until the above mentioned salt has been converted into the neutral phosphate The presence of oxalate of lime is often overlooked.

The occurrence of an excess of these crystals in healthy urine is often due to the ingestion of certain vegetables containing salts of oxalic acid (grapes, apples, oranges, cowberries, tomatoes, sorrel, rhubarb, &c.); to the drinking of waters charged with carbon dioxide; or to the ingestion of alkaline bicarbonates, salts of organic acids, or sugar in large quantities.

Crystals of calcium oxalate are prone to appear in the urine at the end of acid fermentation (generally in association with crystals of uric acid, Plate XXI., Fig. 5); they also occur in cases of diabetes mellitus,* catarrhal jaundice, spermatorrhœa, and during convalescence from severe diseases (particularly typhoid fever, &c.).

* [Fürbringer states that in some cases a distinct alternation has been noted between the amount of sugar and of calcium oxalate excreted, a condition to which the term "*vicarious oxaluria*" has been applied.]

[In spermatorrhœa, precipitation of oxalate of lime does not take place until the spermatic fluid has become mixed with the urine. *Gallois* has shown that the semen is free from crystals of oxalate of lime. The slight albuminuria frequently present in cases of neurasthenia is often associated with the occurrence of oxalate of lime (*Simon*). This is probably the condition referred to by previous writers (*e.g.*, *Robin*) as oxaluria accompanying dyspepsia, with or without hypochondriasis, otherwise **oxaluric dyspepsia.**

Again, in certain ill-defined morbid states the appearance of crystals of calcium oxalate in the urine may be due to an excessive excretion of that salt, independently of any of the above mentioned disorders. To this condition the terms **idiopathic oxaluria** or **oxalic acid diathesis** have been applied (various writers, *e.g.*, *Salkowski* and *Leube*, *Fürbringer*).

Lehmann and *Robin* have also found that oxaluria may be connected with chronic diseases of the lung and pleura.

Woehler and *Frerichs* have shown experimentally that, in man, the ingestion of urate of ammonium causes an increase in the specific gravity of the urine and the deposition of oxalate of lime. The same observers have found that oxalate of lime was increased in the urine of a dog fed on uric acid or after the injection of urate of ammonium into the jugular vein.]

Calcium oxalate crystallises in transparent, colourless, highly refractive, quadratic octahedra of various sizes, frequently having a short principal axis. When seen from above in the direction of the principal axis, these crystals present square outlines with intersecting diagonals, the so-called "envelope" forms.

Less frequently one meets with oval, rounded, or other spheroidal forms; these, when seen on edge, often assume hour-glass, dumb-bell, biscuit, axe-head, or spectacle forms (Plate II., Figs. 2, 3, and 4). The surface of these crystalline masses, which are frequently of a slight yellowish colour, may appear faintly striated. These forms are specially met with in the urine from cases where there has been excessive loss of water from the system (as in profuse diarrhœa, &c.), and also in cases of nephritis and oxalic acid poisoning (Plate II., Fig. 4). In the latter cases, crystals having the form of elongated six-sided plates, frequently arranged in parallel lamellæ, may also be found.

Not uncommonly, oxalate of lime assumes the form of long or short square prisms with terminal pyramids (Plate I., Figs. 4 and 6).

Exceedingly minute octahedra of oxalate of lime can be recognised only when highly magnified; these minute crystals are generally associated with a deposit of urates and of uric acid crystals, but at times may be met with alone.

In cases of jaundice the crystals may have a yellow colour (Plate XXVIII., Fig. 2), and where indigo is present in the urine they are said to assume a dark blue colour.

In cases of oxaluria, where the crystals are present in large quantities, they occasionally give rise to the formation of calculi. The crystals in such cases, are, as a rule, exceedingly minute (Plate I., Fig. 3), and consist of double pyramids, octahedra and irregular forms.

Calcium oxalate crystals are almost insoluble in organic acids; unlike calcium carbonate and ammonio-magnesian phosphate they are insoluble in acetic acid, very slowly soluble in dilute hydrochloric and in dilute nitric acid; they are rapidly dissolved, without effervescence, by strong hydrochloric and nitric acids.

With the small crystals of ammonio-magnesian phosphate they could be confused only by an unpractised observer.

The characteristic "envelope" form, which almost invariably accompanies crystals of other shapes, such as the double pyramid, hour-glass, &c., renders the diagnosis of the latter a simple matter. The oval and specially the rounded forms of calcium oxalate show some similarity to fat drops, since they refract light much in the same way. By the addition of hydrochloric acid, ether, [or osmic acid], it is easy to determine which of the two one has to deal with.

[Oxalate of calcium is found in at least 25 per cent. of all urines, normal or pathological, which have been kept for from twelve to twenty-four hours after micturition.

It may also be found in fresh urine, this occurrence being usually associated with symptoms of irritation of the urinary passages. The presence of a mucous cloud, the surface of which is covered with a thin, translucent, finely granular, slightly glistening layer, almost invariably indicates the presence of oxalate of lime. The sediments containing oxalate of lime suspended in mucus are usually finely granular, flocculent, translucent, whitish, and when examined in proper light the presence of crystals is indicated, notwithstanding their smallness, by minute flashes of light, appearing and disappearing when the specimen is agitated. In very rare cases oxalate of lime is sufficiently abundant to form a thin compact crystalline, whitish layer at the bottom of the vessel; such a sediment is generally composed of large crystals.

As *Golding Bird* has pointed out, oxalate of lime has a great tendency to become deposited on the surface of anything capable of forming a nucleus; thus it becomes deposited on fine threads, on shreds of mucin, &c., which may be floating in the urine, making them appear as if they had been powdered (powdered wig deposit).

When oxalate of lime is precipitated along with other substances its presence is generally hidden by them until the sediment is examined microscopically.

As oxalic acid may be produced by oxidation of uric acid or of some antecedent of that body, its presence in the urine should have some relation to the metabolic changes taking place in the tissues; the well-known effects of diet on the excretion of oxalic acid do not in the least invalidate this supposition.

With the object of obtaining some data regarding the prevalence of oxalate of lime, the editor has tabulated the results of the analyses of 1400 * specimens of urine examined by him in the course of three years. Out of these, 619 only were submitted to minute microscopical examination. The others were either free

* A much larger series was available, but this number of examinations seemed sufficiently large to obtain reliable indications.

from sediment when fresh, or gave on chemical analysis no evidence of morbid changes. On the other hand, in nearly every one of the 619 specimens examined microscopically, there was something abnormal—*i.e.*, albumen, sugar, bile, indican, excess or defect of urea, or some characteristic sediment.

In 182 or 29 per cent. of these selected urines, oxalate of lime crystals were found in sufficient quantity to make their presence evident without any very special search being made for them.

To obtain a more accurate idea of the actual prevalence of crystals of oxalate of lime (whether in large or in small quantities) in abnormal urines, a searching microscopical examination was made of some 200 specimens, and it was found that in 40 per cent. of these cases typical crystals were present ; in about one-fourth of that number the crystals were very scanty.

The following table shows the seasonal prevalence :—

Month.	No. of Specimens containing Oxalate of Lime per cent. of Specimens examined during each Month in Three Consecutive Years.		
January, ...	34		
February, . . .	14	average for the three months,	21 per cent.
March, ...	23		
April, ...	26		
May, ...	35	average for the four months,	40 per cent.
June, ...	42		
July, ...	33		
August, ...	40		
October, ...	24	average for the three months,	23 per cent.
November, . . .	22		
December, . . .	22		

This table indicates that during the summer months, oxalate of lime sediments occur nearly twice more frequently than at other times of the year. This increased incidence does not seem to coincide exactly with any particular fruit or vegetable season. The precipitation of oxalate of lime may be favoured in summer by the more rapid onset of fermentative changes in the urine after it has been voided, but this cannot have a very considerable effect in this series, as the urines were usually examined very early after evacuation.

Owing to the holiday season the number of specimens examined in September was too small to allow of any percentage being calculated ; for the same reason, the number of specimens examined in January was smaller than the number examined in any other month ; it is, therefore, difficult to state positively whether the increase observed during that month was the result of the Christmas festivities, or of some other cause.

With regard to the association of oxalate of lime with other products, the following figures may prove of interest :—

Relation of Precipitates of Oxalate of Lime to other Urinary Precipitates.*

Oxalate of lime with mucus only,	46 cases,	*i.e.*,	25 per cent.	
,, ,, uric acid,	38 ,,	,,	20 ,,	
,, ,, urates,	37 ,,	,,	20 ,,	
,, ,, phosphates,	24 ,,	,,	13 ,,	
,, ,, tube casts,	21 ,,	,,	11 ,,	
,, ,, red blood-corpuscles (3 female cases only),	20 ,,	,,	11 ,,	
,, ,, pus-corpuscles,	15 ,,	,,	8 ,,	
,, ,, spermatozoa,	7 ,,	,,	4 ,,	
Albumen, abundant or pretty abundant,	35 } 99 ,,	,,	19 } 54 ,,	
,, scanty but more than doubtful trace,	64 }	,,	35 }	
Glucose, abundant,†	14 ,,	,,	8 ,,	
(,, slight excess, unimportant,	(28) ,,			
Indican, in very large amount,	1 ,,	,,	0·5 ,,	

With regard to the total amount of solids present in these urines, the following table of the specific gravity of 175 of the specimens examined will show that oxalate of lime is very often associated with the excretion of an excess of solids.

Specific gravity 1015 and above 1005,	7,	*i.e.*, 4 per cent.
,, ,, 1020 ,, 1015,	34,	,, 19 ,,
,, ,, 1025 ,, 1020,	63,	,, 36 ,,
,, ,, 1030 ,, 1025,	54,	,, 30 ,,
,, ,, 1035 ,, 1030,	15,	,, 8 ,,
,, ,, 1040 ,, 1035,†	2,	,, 1 ,,

In the cases in which the high specific gravity was not due to the presence of glucose (7 cases) the increase was chiefly caused by an excess of urates or of urea. (The quantities of urea found in the limited number of cases in which an estimation was made varied from 1·70 per cent. to 5 per cent.; the latter was observed in one case only.)

From the above data it will be evident that the precipitation of oxalate of lime is often associated with pathological changes in the urine and specially with changes indicating faulty metabolism. It must not be overlooked, however, that the results tabulated above relate only to urines which had been selected on account of their presenting some abnormal feature.

It is doubtful whether the generally received view, that oxalate of lime is held in solution owing to the presence in the urine of acid phosphate of sodium, is satisfactory. We know that the precipitation of oxalate of lime is not in itself an index of the amount of oxalic acid present in the urine; it is, therefore, necessary that lime should also be present in sufficient amount and suitable combination to permit the precipitation of the oxalate. Oxalic acid

* In this table some cases have been entered under two heads when two important products (such as, for instance, pus and tube casts) were found in the same specimen. On the other hand, no notice has been taken of the occurrence of *very small quantities* of certain products, such as red blood-corpuscles, or spermatozoa.

† The presence of glucose accounted for the high specific gravity of the only two specimens which had a specific gravity above 1035 (viz., 1036 and 1039 respectively); five of the remaining specimens containing glucose had a specific gravity above 1030, the other seven had a specific gravity below 1030.

itself is capable of various combinations; the various oxalates of potassium are well known to the chemist.

Potassium oxalate, $C_2O_4K_2 + H_2O$, is easily soluble in water.

Potassium hydrogen oxalate, $C_2O_4\,KH$, which occurs in many vegetable cells, is less soluble.

Potassium quadroxalate, $\left.\begin{matrix} C_2O_4\,KH, \\ C_2O_4\,H_2, \end{matrix}\right\} + 2H_2O$, is the least soluble of the three.

The combinations of oxalic acid with calcium, and their relative solubilities, are not so well known, but, as will be shown further, all the oxalate of calcium precipitates found in urine have not the same composition.

We have evidence to show that several of the products excreted by the kidneys are capable of considerable alterations after passing through that organ, and that they may undergo various intermediary changes before reaching their most stable state.

Such changes certaiuly take place in urine after it has been exposed to the action of bacteria; some must also take place in the kidney and urinary passages, independently of bacteria, and possibly under the influence of unorganised ferments. All the changes taking place in the urine after it has been secreted cannot be accounted for by supposing that they are the simple results of double decompositions.

Oxalate of lime is often thrown down abundantly during the acid fermentation, but it may be precipitated in feebly acid or neutral urines.

The relative amount of acidity observed in 171 specimens containing crystals of oxalate of lime was as follows:—

Acidity strong	in	30	or 17	per cent. of the cases.
,, normal (or very slightly increased)	,,	101	,, 59	,, ,,
,, slightly diminished	,,	30	,, 17	,, ,,
Reaction neutral	,,	8	,, 4·6	,, ,,
,, alkaline	,,	2	,, 1·17	,, ,,

These figures do not lend much support to the view that oxalate of lime becomes preeipitated when the acid phosphate of sodium has become neutral by the replacement of 1H by 1Na.

When oxalate of lime is rapidly precipitated it assumes the form of needles, generally grouped so as to form dumb-bells, biconcave ellipsoids, or discs. Similar needle-shaped crystals are found in plants where they produce raphides in the cells; *Holzner* has shown that the behaviour of these crystals towards polarised light indicates their derivation from the oblique rhombic prism.

When these rounded forms are kept under observation it is often found that they gradually disappear, and are replaced by typical octahedra, which evidently correspond to a more stable combination. These octahedra are derived either from the cube or from the straight square prism (the latter type is indicated by the occurrence of octahedra with a short principal axis, and of square prisms with pyramidal endings).

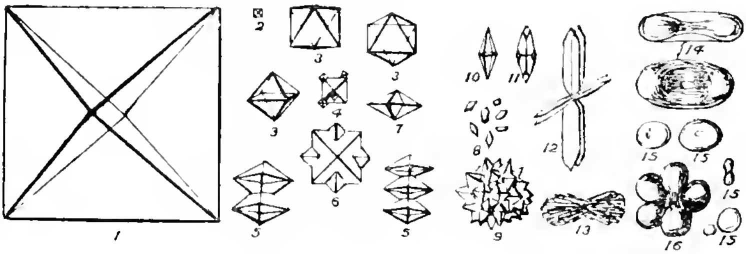
This transformation, the difference of action of the two forms of crystals on polarised light, and actual chemical analysis show that the octahedral and the dumb-bell or acicular forms have not the same composition. Whether the differ-

ence is due to the quantity of water of crystallisation, as admitted by botanists, or to the existence of a series of oxalates of lime comparable to the series of oxalates of potassium is not clear.

Both forms of oxalate of lime may be observed side by side in a large number of urines, but when one form occurs alone it is usually the octahedral form.

In 180 specimens examined to ascertain the relative prevalence of these two forms, it was found that

The octahedral forms alone (or nearly so) occurred . .	in 135 specimens.
,, octahedral and oval or dumb-bell forms together . .	,, 42 ,,
,, dumb-bell or oval forms quite alone	,, 1 ,,
Small concretions with ill-defined crystals	,, 2 ,,



EXPLANATION OF FIG. 2.

Types of Oxalate of Lime Crystals found in Urine.

All these outlines are enlargements of drawings made with the assistance of the camera lucida ; the scale corresponding to a magnification of 690 diameters.

A. Regular Octahedron Type.

1. Typical octahedron, the largest observed in the course of about 2000 microscopical examinations.
2. Typical octahedron of very small size, but not the smallest observed.
3. Various appearances presented by octahedra in various positions.
4. Growth of small octahedra on the surface of a larger octahedron.
5. Contact twins, seldom observed.
6. Penetration twin, apparently a combination of an octahedron with short principal axis with another having a longer principal axis.
7. Octahedron with short principal axis, lateral view.
8. Crystalline particles imperfectly crystallised.
9. Concretion, microscopical calculus.

B. Atypical Forms.

10. Elongated octahedron.
11. Elongated octahedron, with various angles truncated

C. Acicular Crystals and Rounded Groups.

12. Elongated, irregular hexagonal plates having the same solubility as oxalate of lime crystals, and found in a sediment containing other forms of oxalate of lime and nothing else. The quantity was, however, too small for accurate chemical analysis.
13. Group of acicular crystals forming a dumb-bell, showing the effect of partial solution of a typical dumb-bell crystal.
14. Ellipsoid oxalate of lime, side and front view.
15. Smaller, rounded and dumb-bell forms.
16. Concretion made up of dumb-bells and rounded masses.]

Sulphate of Lime. Calcium Sulphate.

(Plate III.)

Sulphate of lime crystals are extremely rare in urinary sediments. They are, as a rule, met with in strongly acid urine, where they form a dense white deposit. They take the form either of long thin, colourless needles or prisms, or of elongated plates, with obliquely cut ends, which may be isolated or arranged in the form of rosettes or twin crystals (Plate III., Fig. 1). From a diagnostic standpoint the similarity of the sulphate of lime crystals to those of dicalcium phosphate should be remembered. Their insolubility in ammonia, acetic and sulphuric acids, as well as their slight solubility in nitric and hydrochloric acids, make the distinction between these two salts easy.

[In the literature only three cases are on record—viz., those published by *Valentiner*, *Fürbringer*, and *v. Jaksch*; in the two former the urine was strongly acid and the deposit had the characters described above; in v. Jaksch's case the calcium sulphate was associated with triple phosphate and carbonate of lime, a condition inconsistent with any marked acidity of the urine.]

PHOSPHATES.

(Plates III., IV., V., IX., XXI., and XXII.)

These salts occur in two forms, amorphous and crystalline, which are not infrequently present together in the same urine.

[The presence of phosphates in urines which have been allowed to stand for some days, and in which alkaline fermentation has taken place, has no clinical significance.

On the other hand, it is well known that there may be increased excretion of phosphates without any precipitation taking place.

The presence of phosphatic sediments has, therefore, in many cases a very slight clinical importance. There are, however, patients in whose urine phosphatic sediments form so readily and rapidly after the urine has been voided that their occurrence is worthy of some attention. When there is no evidence of disease of the urinary organs, an abundant and rapid precipitation of phosphates may indicate some disturbance of metabolism. The only reliable way, however, to determine whether there is **phosphaturia** or not is to estimate the amount of phosphoric acid in the urine.

Sediments of phosphates may occur under the following conditions:—

1. Alkaline fermentation of the urine, after it has been voided.
2. Alkaline fermentation of the urine in the urinary passages, as in certain cases of cystitis. When, in addition to the crystals, pus (or muco-pus) and blood are also found, the presence of a calculus may be suspected.

3. Alkalinity of the urine, associated with the ingestion of alkalies, alkaline salts of vegetable acids. Resorption of blood, or of inflammatory exudations (*Bizzozero*).
4. Certain disturbances of body metabolism.

According to *Bence-Jones*, the administration of lime water or acetate of lime may cause a deposit of crystalline phosphate of lime in the urine.]

Amorphous Earthy Phosphates. Calcium and Magnesium Phosphates.

(Plates III., IV., and IX.)

They are deposited from alkaline (or neutral) urines. [But sometimes they are found in slightly acid urines, as is also the case with crystallised dicalcium phosphate.] They occur in the form of colourless amorphous masses, consisting of fine granules or spheres of various sizes, aggregated in irregular groups (Plate III., Figs. 2 and 3; Plate IV., Fig. 1). Macroscopically, the greyish-white phosphatic sediment (Plate IX., Fig. 2) may be mistaken for pus. This deposit has usually no pathognomonic significance.

The granules dissolve on the addition of acids—*e.g.*, acetic acid; they are not dissolved on heating; on the contrary, phosphates are precipitated in still greater quantity when a urine rich in these salts is heated; this precipitation is attributed to the liberation of carbonic acid gas.

From amorphous urate granules of similar size they are readily distinguished by the above reactions, by the absence of colour, and by their occurrence in alkaline or neutral urines, generally along with crystals of triple or of stellar phosphate. Amorphous urates, on the other hand, are coloured, occur usually in acid urines, and are very frequently associated with crystals of uric acid.

Neutral Magnesium Phosphate. Tri-magnesium Phosphate.

(Plate III.)

Crystals of this phosphate are of very rare occurrence. They are met with in urine concentrated and alkaline,* but in which the ammonia is not increased (*i.e.*, not in a state of ammoniacal fermentation). This deposit has been found in cases of dilatation of the stomach (*Gastrectasia*). The crystals first described by *Stein* † have the form of large highly refractive, elongated rhomboid plates (Plate III., Figs. 4 and 5) sometimes having obliquely cut ends. They are often visible to the naked eye as small glittering crystals. In many cases two crystals with straight or oblique ends occur in close apposition. Other crystals resemble square plates, whilst others carry at their poles bunches of acicular crystals evidently of more recent formation. Some of the crystals may have irregular eroded edges and rough shagreen-like surfaces.

Crystals of this salt not only occur in the sediment but may also be found in the crystalline pellicle which is apt to form on the surface of the urine.

[* Alkaline, neutral, or slightly acid concentrated urine (*Stein*).]
† *Deutsches Archiv f. klin. Med.*, Bd. xviii.

In form, the crystals resemble those of calcium sulphate, but they never occur in rosettes; they are also, unlike the latter, readily soluble in acetic and other acids; they are insoluble in caustic potash or soda.

When ammoniacal fermentation begins in a urine containing a precipitate of tri-magnesium phosphate, crystals of ammonio-magnesium phosphate are gradually formed. The same thing occurs when the precipitate is treated with ammonia.

The author has not been able to confirm the statement made by Stein, that a 20 per cent. solution of ammonium carbonate rapidly produces disintegration of the tri-magnesium phosphate crystals. According to that observer, the action of the ammonium carbonate manifests itself by erosion of the edges and a roughening of the surface giving rise to the "shagreen" appearance. "Coffin-lid" crystals similarly treated would remain unaltered. Such a change, however, does occur in the crystals after they have stood some considerable time in the urine, as is shown in a few of those represented in Plate III., Figs. 4 and 5.

Dr. Weinschenk has ascertained the nature of the crystals represented in the plate by means of their optical characters (slight double refraction, crystalline angle nearly 60°) and of their micro-chemical reactions (demonstration of phosphoric acid by ammonium molydate, and of magnesia by the addition of ammonia to the acid solution). The crystals represented on Plate III., Figs. 4 and 5, are identical with those described by Stein.

> [Similar crystals have also been described by *Hassall* and *Golding Bird* twenty-three years before the publication of Stein's paper. Both these observers noted them as occurring in the clear alkaline urine from cases of dilatation of the stomach, in which *Sarcinæ ventriculi* had been found, and which were being treated with hyposulphite of soda. The composition of the crystals was also ascertained by chemical examination.]

"Neutral" Phosphate of Lime. Dicalcium Phosphate.

(*Stellar Phosphate.*)

(Plates II., III., IV., and XXI.)

Deposits of this salt occur not uncommonly in light-coloured, neutral, amphoteric, or slightly acid urines containing large quantities of calcium phosphate. It is at times met with in healthy urine possessing these characters, but is more common in connection with diseases in which the articulations are affected (especially rheumatic affections), anæmia and chlorosis.

The crystals are usually wedge-shaped or pointed at one end (Plate IV., Fig. 2). They occur either singly or arranged in rosette-like groups (frequently incomplete), the points of the crystals being directed towards the centre **[stellar phosphate].** Occasionally, the crystals are arranged in the form of fans, sheaves, flowers, or nodular masses (Plate IV., Figs. 3 and 4). Rarely, they are thin and needle-shaped and then may form tyrosin-like tufts (Plate II., Fig. 5). From tyrosin they are readily distinguished by their solubility in acetic acid and also by the more abrupt convergence of the needles towards the apex of the tuft. When

sheaves are formed, this occurs by the apposition of the apices of two distinct tufts and never by the crossing of a series of needles through a common centre, as in tyrosin.

The crystals of dicalcium phosphate are readily dissolved by acetic acid. They gradually disappear from the urine when alkaline fermentation occurs.

This salt also enters in the formation of thin pellicles or flakes having irregular curved borders (Plate III., Fig. 6 ; Plate IV., Fig. I ; Plate XXI., Fig. 4), produced by the breaking up of the opalescent crystalline film which sometimes forms on the surface of neutral, slightly acid, or alkaline urine. In bile-stained urine this pellicle has a yellowish colour.

Both forms, crystals and flakes, are often associated with amorphous phosphates (Plate III., Fig. 6 ; Plate IV., Fig. 1), and sometimes also with ammonio-magnesian phosphate (Plate IV., Fig. 1).

[Chemically speaking this salt is not a *neutral*, but is really an *acid*, phosphate ; medical and other writers have, however, usually called it neutral.

Three kinds of phosphate of calcium may occur in urinary sediments—

1. Monocalcium (or calcium dihydrogen) phosphate, or diacid phosphate of calcium, $Ca(H_2PO_4)_2$. This salt is crystalline ; it is of very rare

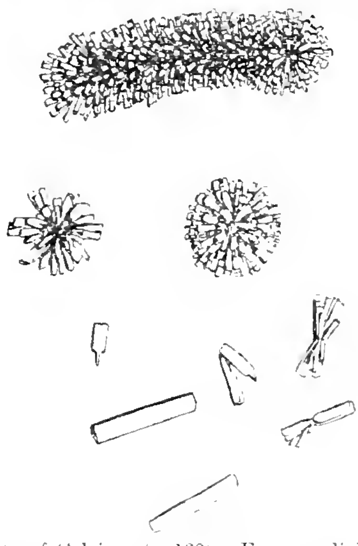


Fig. 3.—Stellar Phosphate of Calcium (× 160).—From a slightly acid urine in which the salt formed an abundant white sediment.

occurrence and is found in strongly acid urines of high specific gravity, frequently associated with uric acid.

2. Dicalcium (or calcium hydrogen) phosphate, or stellar phosphate, $CaHPO_4$, which is the most usual form ; it is this acid phosphate which is so often termed neutral ; it is found in slightly alkaline, neutral, or slightly acid urines. It seldom forms very abundant sediments, but may occasionally produce large compound crystalline masses (see Fig. 3).

3. Tricalcium phosphate, or neutral (normal) phosphate, $Ca_3(PO_4)_2$, which occurs in alkaline urines, ammoniacal or not, and is amorphous (see also *Halliburton*, *Simon*, &c.).]

Ammonio-magnesian Phosphate. Ammonium-magnesium Phosphate.

(*Ammonio-phosphate of Magnesia*, *Triple Phosphate*).

(Plates IV., V., X., XXI., and XXII.)

This salt usually occurs in alkaline urine, particularly during ammoniacal fermentation; it forms the principal constituent of the white deposit characteristic of that condition. It may also be met with in slightly acid or amphoteric urines. Not unfrequently it is associated with a deposit of acid ammonium urate or of amorphous phosphates.

Triple phosphate separates in the form of transparent, colourless, highly refractive, three-, four-, or six-sided prisms of various sizes and having oblique terminal surfaces, the crystals often assume a shape which has been compared with that of a coffin lid [these forms are derived from the straight rhomboidal prisms] (Plate IV., Fig. 1; Plate V., Fig. 1; Plate XXI., Fig. 6; Plate XXII., Figs. 1-4). Many crystals deviate more or less from these simpler forms; they may be incompletely formed and may present a sledge-like appearance (Plate V., Fig. 3). [Twinning of the crystals is frequent.]

In bile-stained urine which has stood for some time, many of the crystals assume a yellowish colour (Plate X., Fig. 3). Sometimes crystals having a feathery appearance or the form of intersecting fern leaves are met with, but they are comparatively rare (Plate IV., Fig. 6; Plate V., Figs. 2 and 3). The latter and other similar forms can be readily produced by the addition of ammonia to urine, when the crystals separate out in the form of a white cloud or as a white deposit (Plate IV., Fig. 5). [This precipitate may be obtained in any recently voided urine and indicates the presence of phosphate of magnesium in solution.]

Triple phosphate crystals are readily soluble in acetic acid.

[**General Remarks on the Occurrence of Phosphates.**—To obtain some data regarding the occurrence and significance of phosphatic sediments, the editor has classified the results of 600 chemical and microscopical examinations of urines. This series of analyses is the same as that used with reference to the sediments of oxalate of lime.* Almost all these specimens were examined less than twenty-four hours after the urine had been voided, and at least three-fourths of the total number within six to twelve hours; therefore, the effects of ammoniacal fermentation outside the bladder may be, in most of these cases, excluded. As previously explained, these 600 specimens were selected out of a much larger number of samples, because their physical and chemical characters suggested th existence of some morbid state.

* By excluding the few analyses made during the months of August and September, the number of samples used has been reduced from 619 to 600.

The results of the microscopical examination may be summarised as follows with regard to the presence of phosphates :—

Number of Cases in which Phosphates were found in the form of a precipitate (out of 600 samples), ... 93 ; *i.e.*, 15·5 per cent.

The composition of these sediments was—

Crystals of triple phosphate, mixed in a few cases with amorphous phosphates, ...	44 ;	*i.e.*, about 7·3 per cent.
Crystals of triple and stellar phosphates mixed, . . .	8 :	,, ,, 1·3 ,,
Crystals of stellar phosphate alone or mixed, in a few cases, with amorphous phosphates, ...	29 ;	,, ,, 4·8 ,,
Trimagnesium phosphate crystals, ...	1 ;	,, ,, 0·16 ,,
Abnormal crystals giving reactions of phosphates, but not fully investigated, ...	2 ;	,, ,, 0·32 ,,
Amorphous phosphates, without any phosphatic crystals, .	9 ;	,, ,, 1·5 ,,

One is struck at times by the large number of consecutive cases in which sediments of phosphate of lime seem to take, partly or completely, the place of other crystalline sediments, more specially of oxalate of lime. But when the results of several years' observations are thrown together, no clear relation between seasons and the prevalence of certain forms of phosphatic sediments can be established. This, of course, does not exclude the possibility of temporary meteorological or other general influences.

The following table shows the *proportion of urines containing phosphatic sediments for each month* (based on three years' observations) :—

	Phosphate of Lime.	Ammonio-magnesium Phosphate.	Total.
January, ...	about 4 per cent.	about 12·5 per cent.	16·5
February, ...	,, 6 ,,	,, 6 ,,	12
March, ...	,, 9 ,,	,, 6·6 ,,	14·6
April, ...	,, 5 ,,	,, 11 ,,	16
May, ...	,, 9 ,,	,, 6 ,,	15
June, ...	,, 7 ,,	,, 6 ,,	13
July, ...	,, 4·5 ,,	,, 7·5 ,,	12
August and September numbers insufficient for a proper estimation.			
October, ...	about 6 per cent.	about 8 per cent.	14
November, ...	,, 9 ,,	,, 9 ,,	18
December, ...	,, 3·6 ,,	,, 9 ,,	12·6

At most this table indicates a slight increase of triple phosphate and a decrease of phosphate of lime during the winter months.

Some of the *associations of phosphates* are interesting. Thus, in twelve out of the twenty-nine sediments in which dicalcium phosphate was the only crystalline phosphate present, *oxalate of calcium* was also found. That is to say, oxalate of lime was present in 40·8 per cent. of these cases.

On the other hand, out of forty-four sediments in which crystals of triple phosphate were the only form of phosphatic deposit, only three, or 6·6 per cent., contained also crystals of oxalate of lime.

Spheroidal or "hedgehog" masses of urates were found in 20 per cent. of the urines containing triple phosphate crystals.

The finely granular or amorphous urates were very rarely found associated with the triple phosphate.

Urate of calcium was found in one out of 37 cases in which phosphate of lime was also present.

Carbonate of calcium was present in the form of small rounded granules, once associated with amorphous phosphates, and once with phosphate of calcium, and phosphate of ammonium and magnesium; in both cases the urine was neutral or nearly so.

The other points of interest may be tabulated as follows:—

A. Number of cases in which albumen, pus, or blood were found associated with crystals of triple phosphate (no other crystalline phosphates being present).

Total number of sediments containing triple phosphate crystals, ...	44
Albumen present in moderate or large amount (traces excluded), ...	in 34 or 75 per cent. of the cases.
Pus (generally stringy),*	,, 27 ,, 60 ,, ,,
Blood, ...	,, 6 ,, 13 ,, ,,

B. Number of cases in which albumen, pus, or blood were found associated with crystals of phosphate of calcium (no other crystalline phosphates being present).

Total number of sediments with stellar phosphates,	29
Albumen present, ...	in 11 or 38 per cent. of the cases.
Pus, ...	,, 6 ,, 20·7 ,, ,,
Blood, ...	,, 2 ,, 7 ,, ,,

It seems probable from these figures that the deposition of ammonio-magnesian phosphate crystals is determined in a large proportion of cases by local conditions affecting the urinary passages. The precipitation of phosphate of calcium is apparently determined in many of the cases by other causes.

The same difference is indicated also to a certain extent by the state of the urine as evidenced by the specific gravity and the reaction.

Specific gravity and reaction of urines in which ammonio-magnesian phosphate crystals were the only crystalline phosphatic constituents of the sediment.

Specific gravity 1010 and below, . . .	in	4	or about	10 per cent. of the cases.
,, 1015 and above 1010, . .	,,	9	,,	21 ,, ,,
,, 1020 ,, 1015, . .	,,	9	,,	21 ,, ,,
,, 1025 ,, 1020, . .	,,	16	,,	38 ,, ,,
,, 1030 ,, 1025, . .	,,	3	,,	7 ,, ,,
,, 1035 ,, 1030, . .	,,	1	,,	2 ,, ,,
Total number of cases examined, . .		42		99

* Triple phosphate crystals were found in only about 22 per cent. of all the cases in which pus was present.

Reaction alkaline,	in 32	or about 71·3	per cent.	of the cases.
Neutral or amphoterous,	,, 10	,, 22·3	,,	,,
Acid (feebly),	,, 2	,, 4·4	,,	,,
Total number of cases examined,	44	,, 98·0	,,	,,

Specific gravity and reaction of urines in which calcium phosphate crystals were the only crystalline phosphatic constituents of the sediment.

Specific gravity 1010 and under,			in 0			
,,	1015 and above 1010		,, 1	or about 3·4	per cent.	of the cases.
,,	1020 ,,	1015	,, 10	,, 34·5	,,	,,
,,	1025 ,,	1020	,, 8	,, 27·6	,,	,,
,,	1030 ,,	1025	,, 9	,, 31	,,	,,
,,	1035 ,,	1030	,, 1	,, 3·4	,,	,,
Total number of cases,			29	,, 99·9	,,	,,

Reaction alkaline,	in 6	or about 20·7	per cent.	of the cases.
Neutral,	,, 4	,, 13·8	,,	,,
Acid (feebly),	,, 19	,, 65·5	,,	,,
Total number of cases,	29	,, 100·0	,,	,,]

Uric Acid.

(Plates II., V., VI., VII., IX., X., XI., XXII., XXIII., XXIV., XXVI., XXVII., XXVIII., and XXIX.)

Uric acid sediments are not, as a rule, deposited until the urine has cooled below the body temperature, and has, therefore, become incapable of holding large quantities of uric acid in solution.*

Uric acid occurs generally in urines of acid reaction; [but uric acid crystals may also be found in alkaline urines in the early stages of the alkaline fermentation; they are then more or less altered, owing to partial solution.]

It is usually precipitated during the acid fermentation.

The crystals are deposited in urines of great concentration [deposits of uric acid are, however, far from uncommon in urines of low specific gravity], such, for example, as are voided after a diet rich in proteid food, when insufficient exercise is taken, or after profuse sweating, as during the summer months; uric acid is more frequent in dark coloured urines, in which it is often associated with urates, than in light coloured urines free from uratic sediment.

A deposit of uric acid as a consequence of mere concentration of the urine has generally no particular significance. But this is not the case when its occurrence depends on an increased formation and excretion. Such a sediment is frequently observed in febrile diseases after febrile crises, in acute rheumatic arthritis, in the uric acid diathesis, in renal and vesical lithiasis (when the calculus formation is due to the deposition of uric acid and urates), in leukæmia, pernicious anæmia, diabetes, passive venous congestion, and in all conditions in which there is respiratory insufficiency.

* For a discussion of this statement see p. 27.

[It is difficult to support the view that precipitation of uric acid is simply due to the cooling of the urine. It is undoubtedly true that uric acid is more soluble in hot than in cold water, but the deposition of crystals usually begins after the fluid has become cold, and when, owing to acid fermentation, the acidity of the fluid is increasing. *Prout* has shown that urine freshly voided often contains far more uric acid than an equal quantity of water could hold in solution.

On the other hand, the addition of a small quantity of an acid causes a rapid precipitation of uric acid crystals, which may easily be redissolved by further addition of a slight excess of alkali.

It is generally admitted that uric acid is not free at the time the urine is voided, and this view is further supported by the fact that cooling, when it causes any precipitation, brings about the deposition of amorphous urates, and not of uric acid. Concentration of recently voided urine, as by evaporation *in vacuo*, also causes separation of urates and not of uric acid. That the amorphous precipitate is not one of *hydrated uric acid*, as was believed formerly by some eminent chemists (*Berzelius, Thenard*, &c.), is easily proved by incinerating a small quantity of the precipitate (thoroughly washed with distilled water) on platinum foil. The white residue which is left is alkaline; and the amount of base it contains is quite large enough to produce with uric acid a soluble combination (*Icery*, see *Robin*).

The amorphous precipitate is also readily redissolved on heating, and separates again when the fluid cools. Hydrated uric acid behaves very differently. *Thudichum* states that it is a product which may be separated from concentrated urines on the addition of an acid. This precipitate is gelatinous, and becomes crystalline after standing some time, or immediately on heating.

Sir Wm. Roberts explains the precipitation of uric acid in the following way: —Urates exist in urine, before it has left the body, under the form of quadrurates. These salts are easily broken up by the action of the water of the urine.

$$\underset{\text{Quadrurate.}}{(MHU\,.\,H_2\overline{U})} + \underset{\text{Water.}}{H_2O} = \underset{\text{Uric acid free.}}{(H_2U)} + \underset{\text{Biurate.}}{(MHU)^*}$$

The whole uric acid might, in the same way, be liberated by the further transformation of biurates into quadrurates in the presence of the dimetallic phosphates. *Sir Wm. Roberts* says:—

"By these alternating reactions all the uric acid is at length set free.

"Seeing that uric acid exists in acid urine amid conditions which, if the quadrurates stood alone and uncontrolled, would lead to its immediate precipitation, and yet that in the normal course no such early precipitation occurs, it is obvious that the urine must contain certain ingredients which inhibit or greatly retard its water from breaking up the quadrurates. These inhibitory ingredients consist chiefly of (1) the mineral salts, (2) the pigments of the urine.

"The conditions of the urine which tend to accelerate the precipitation of uric acid, as in the formation of concretions and deposits are:—(1) High acidity; (2) poverty in mineral salts; (3) low pigmentation; (4) high percentage of uric acid.

* In this formula M means metal, and $\overline{U}$ uric acid.

The converse conditions tend to retard its precipitation." It will be noticed that Sir Wm. Roberts' views do not agree with the statements made by Dr. Rieder and many other urinologists. The editor has found, as a result of a large number of observations, that uric acid is very frequently deposited in urines of low specific gravity, and but slightly pigmented.]

Crystals of uric acid occurring in physiological and pathological urines, either alone or along with other deposits, especially uratic sediments, present manifold variations both in size and form.

Not infrequently they are visible to the unaided eye as ruby-red, brick-red, or golden-yellow crystals clinging to the sides of the urine vessel, and often attaining the size of a pin's head; they depend for their colour on the urinary pigments [specially uroerythrin]. In certain cases in which the urine is pale, the crystals may be colourless; pale uric acid has been specially noticed in connection with leukæmia (Plate V., Fig. 5). In rare instances they have a bluish or violet colour, owing to the presence of indican derivatives; or they may be of a greyish-violet or blackish colour after the exhibition of salicylic acid, salol or phenol (Plate V., Fig. 4).

Under the microscope uric acid appears as yellow, yellowish-green, brown or brownish-violet crystals, whose fundamental form is the rhombic prism. From this type numerous modifications arise; thus by the rounding off of the two opposite obtuse angles the so-called whetstone and spindle forms are produced. Crystals of the former type, which is probably the most common, are often arranged in rosette-like groups (Plate IX., Figs. 3, 4, and 5). Should the two acute angles be truncated, six-sided plates are produced (Plate V., Fig. 5; Plate IX., Fig. 2; Plate XXVI., Fig. 1). Barrel forms (Plate XXI., Fig. 5; Plate XXII., Fig. 6) may be regarded as produced by the superposition of plates; whilst by various groupings and crossing of crystals, small concretions, rosettes, and sunflower forms are produced (Plate IX., Figs. 4, 5, and 6). Irregular varieties are also met with in the urine; they can generally be recognised by the yellowish colour of the crystals, by the co-existence of regular forms and by micro-chemical tests (see p. 30).

Occasionally one meets with flask-shaped or conical masses (Plate X., Fig. 1); or sheaves of rod-shaped crystals (Plate VI., Fig. 1); or the crystals may be acicular and arranged in larger and smaller sheaves and rosettes (Plate II., Fig. 6).

These latter forms may be produced artificially by the addition of an acid,—*e.g.*, acetic acid, to sodium urate or to a urine rich in urates.

In a strongly acid urine which has stood for some time one occasionally meets with uric acid crystals in the form of dumb-bells, hour-glass or other forms produced by twinning and other grouping of crystals.

[It should be kept in mind that urates may form acicular crystals grouped in various ways (see *Urates*, pp. 35 and 36).]

In some cases, especially in the uric acid diathesis and in cases of renal lithiasis, one meets with spear-shaped crystals produced by the elongation of the acute angles of the original rhomb; these may be either arranged in groups or attached to other crystals,

giving to the latter a spinous appearance (Plate XXIII., Fig. 3; Plate XXIX., Fig. 1), or they may give rise to the so-called "comb-forms" (Plate XI., Fig. 1).

Generally, the more irregular and spear-like varieties occur in urines of strongly acid reaction, whilst the characteristic small barrel-shaped and whetstone forms are more frequently met with in urines of less acidity.

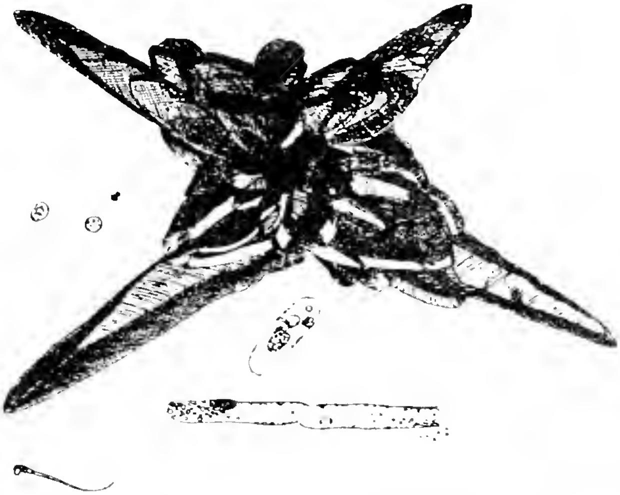


Fig. 4.—Uric Acid, Oxalate of Lime, Casts, Leucocytes, and one Spermatozoon (× 210). From a case of Chronic Bright's Disease.

[The differences between these two types of crystals are well shown in Figs. 4 and 5. Fig. 4 represents the elements of the sediment found in a strongly acid urine containing a large amount of albumen, from a case of chronic Bright's disease. The sediment represented in Fig. 5 was found in a urine moderately acid, containing much albumen; also from a case of Bright's disease, but in an acute stage.]

Fig. 5.—Small Pale Crystals of Uric Acid, also Oxalate of Lime, Tube Casts, and Vesical Cell (× 150). From a case of acute Bright's disease.

Uric acid may also occur in the form of four- and six-sided colourless plates of varying size, particularly in leukæmia (Plate V., Fig. 5; Plate XXI., Fig. 4; Plate XXVI., Fig. 1) and in artificial precipitation of the acid. They differ from the somewhat similar cystin crystals in not being imbricated and in not being [rapidly] soluble in ammonia, but they are readily dissolved by caustic potash or soda. In addition to these six-sided plates one finds occasionally other colourless forms, rounded or oval in shape and having a central depression or radial striation (Plate XI., Fig. 2).

[These forms are probably never found in acid urines, and are the result of unequal solution of typical crystals, when the urine has become ammoniacal.]

When uric acid is deposited along with urates, it may be recognised as forming one or several layers, usually of a brick-red colour, differing from the rest of the sediment; a layer of uric acid may lie on the surface of the urates when these have previously formed a compact sediment; alternate precipitation of uric acid and urates leads to the formation of several strata (Plate XI., Fig. 4).

Sometimes the crystals have jagged edges; occasionally a large crystal may seem to contain a small one in its interior, the surfaces of the two being parallel [this appearance is produced when changes in the colour of the pigment occur during the growth or partial solution of the crystal] (Plate IX., Figs. 3 and 4), or the crystal may be marked with striæ which appear like minute cracks in its substance. [These cracks or fissures occasionally present a definite arrangement indicating a subdivision of the crystal into a large number of very small crystals of typical rhombic form. The axes of these small crystals are often oriented exactly like those of the large one which they compose. This appearance is usually observed in crystals which are very slowly undergoing a process of solution] (Plate IX., Fig. 6; Plate XI., Fig. 1). Minute crystals of uric acid may also form loose masses (Plate VI., Fig. 4), or be united so as to form more or less extensive plates.

In bile-stained urines, uric acid is often deposited in the form of spear-shaped or prismatic crystals, of a dirty greenish-yellow colour, arranged in rosettes (Plate VI., Fig. 3; Plate XXIV., Fig. 4); more rarely the crystals may be rod-shaped or acicular (Plate II., Fig. 6).

When uric acid is produced artificially by the addition of an acid to a urine rich in urates, the crystals which appear are generally small, slightly yellow or colourless, of the whetstone type (Plate VI., Fig. 3); more rarely, four- and six-sided plates are produced.

Micro-chemical Reactions of Uric Acid.

Uric acid crystals are readily dissolved by alkalies—*e.g.*, caustic potash and soda (but, unlike the urates, not by a small amount of hot water or by acids), and separate out again on the addition of acetic or hydrochloric acid in various crystalline forms (see p. 28; Plate VI., Fig. 5). These changes do not occur instantly, but require some minutes for their completion.

Like the urates they give the characteristic *murexide reaction*. To obtain this reaction, the crystals of uric acid are cautiously heated with a few drops of concentrated

nitric acid in a porcelain capsule, the fluid is then evaporated to dryness; the residue, which is reddish-yellow, becomes purplish-red on the addition of ammonia, and bluish with caustic potash or soda.

Occasionally, colourless uric acid crystals occur together with crystals of triple phosphate, from which they can be distinguished by micro-chemical tests. Plate XI., Fig. 2, represents the sediment of the strongly alkaline urine, rich in indican, of a woman suffering from carcinoma of the stomach and cystitis. The abnormal crystals of uric acid shown in this figure were comparatively insoluble in ammonia, insoluble in acetic acid, readily soluble in caustic potash, and gave the murexide reaction. In addition to these there were coffin-lid crystals of triple phosphate, readily dissolved by acetic acid. Some of the crystals, both of uric acid and of triple phosphate, had acquired a faint reddish-violet hue, owing to the presence of indican derivatives.

Uric Acid and Uric Acid Salts in Tophi.

(Plates VI. and VII.)

The cretaceous or mortar-like constituents of tophi, which may be expressed through openings in the thin overlying skin, consist of a fine crystalline pulp. By far the greater part of this pulp is made up of acicular crystals of uric acid, which are either scattered irregularly or collected into more or less symmetrical tufts, bundles, or spheroidal masses (Plate VI., Fig. 6; Plate VII., Fig. 1). Now and again one sees among these products small isolated or imbricated six-sided plates of uric acid, closely resembling cystin.

Scattered between the needles are generally many amorphous granules of urates (Plate VII., Fig. 1). The needles are dissolved by alkalies; and, on the subsequent addition of an acid, the uric acid is reprecipitated in the form of whetstones and dumb-bells.

The murexide reaction is easily obtained. The amorphous urate granules dissolve in acids, whilst the needles remain unaltered.

[The editor is unable to follow the views of the author as stated above.

The crystals described here, and those represented in the plates, are generally believed to be composed of urate of soda (*Garrod* and other authorities). *Heintz* had previously noticed that tophi contained *urate of lime*, but little importance has, generally, been attached to that salt.

It is easy to show that gouty uratic deposits are not usually made up of uncombined uric acid. They are, as a rule, readily, though slowly, dissolved by dilute mineral acids, and, after the needles have disappeared, uric acid separates from the acid solution in the form of typical and atypical crystals. This is a characteristic reaction of urates. On the other hand, the acicular crystals do not behave as if they were composed of urate of soda. They are very slowly soluble in hot water, they are slowly affected by organic acids, and, when treated with sulphuric acid in presence of a small amount of water, a double precipitate of uric acid and sulphate of calcium is obtained. Uric acid left for a few days in water containing

a small amount of lime is gradually transformed into urate of lime, which forms bundles of acicular crystals identical in appearances with those found in gouty deposits, and which give exactly the same micro-chemical reactions. Pure uric acid mixed with an excess of lime-water is rapidly transformed into crystalline normal urate of lime identical with those described above. This salt is comparatively insoluble in water. When, on the contrary, an excess of uric acid is added to lime-water, an acid salt is produced which is comparatively soluble in water (see *Urate of calcium*).]

Urates.

Most of these salts may be recognised by their being dissolved when the urine containing them is heated or when acids, such as hydrochloric or acetic acid, are added to it. In the latter case, crystals of uric acid slowly separate out from the solution.

[Freshly precipitated phosphorus urates are very soluble in alkalies. When urine has stood for some time and spheroidal masses of urates have been formed, it becomes, at times, difficult to cause them to dissolve by the action of heat or the addition of alkalies, and they are also less rapidly dissolved by acids; this indicates some alteration in composition.]

The urates of sodium, potassium, ammonium, calcium, and magnesium give the characteristic murexide reaction (see p. 30).

[There are numerous points with regard to the precipitation of urates which deserve careful study, as they indicate the complexity of the changes to which urine is liable immediately after secretion.

Urines which are distinctly acid at the time of being voided, may deposit urates rapidly on cooling; this deposit is seldom very bulky and is almost always associated with a subsequent separation of uric acid crystals. The addition of acid to such urines does not materially increase the amount of precipitable urates, but causes a more rapid separation of uric acid.

There are urines of high specific gravity and feeble acid or neutral reaction, from which urates do not precipitate for some considerable time after complete cooling. If such urines be left undisturbed, they may remain clear for some hours; then, suddenly, they become uniformly cloudy and an abundant sediment of acid urates gradually forms in the course of the following few hours. Whilst this precipitation takes place the urine continues to become more acid. The separation of the amorphous urates in such urines may be brought about rapidly by the addition of very minute traces of acid; thus it is often enough to add 1 part of acetic acid to 400, 500, or more parts of urine to obtain almost instantaneous precipitation of the urates. A large excess of water produces the same effect. In such cases the formation of the precipitate spreads rapidly from the parts which come first in contact with the acid, very much in the way in which crystallisation takes place in supersaturated solutions when a body capable

of acting as a nucleus is thrown into them. If only a small amount of acid has been added, the precipitated urates are entirely redissolved when the fluid is heated. The precipitate re-appears, apparently unaltered, on cooling, and when the amount of acid used has been very small, this process of solution by heating and reprecipitation by cooling may be repeated several times without any marked alteration in the solubility of the sediment.

If, on the contrary, an excess of acid has been used, it is impossible to redissolve the precipitate entirely by warming, and each time the fluid is warmed again a larger proportion of the precipitate becomes insoluble, owing to the separation of uric acid; a few crystals of oxalate of lime may also become evident at the same time.

The generally received explanation of the precipitation of urates is that they are, at the time the urine is voided, normal, and therefore comparatively soluble; under the influence of acid fermentation a redistribution of the base between the urates and other salts, chiefly the acid phosphate of sodium takes place, and the comparatively insoluble acid urates are deposited.

Scherer believed that under the action of a mycodermic ferment, lactic and acetic acid are produced, at the expense of the urinary pigment, during the acid fermentation.

Free carbonic acid is capable of producing the deposition of acid urates when passed through a solution of neutral urates.

Sir William Roberts gives quite another explanation of the formation of acid urates. A summary of his views may be given here.

"Uric acid ($C_5H_4N_4O_3$ or H_2U) is a bibasic acid, and forms two regular orders of salts—namely, neutral or *normal urates* (M_2U), and acid urates or *biurates* (MH_2U). But, in addition to these, it forms a series of hyperacid combinations first discovered by *Bence-Jones*, and termed by him *quadrurates* ($MHU \,.\, H_2\bar{U}$). The normal urates are never found in the animal body, and are only known as laboratory products. The biurates are only encountered pathologically as gouty concretions. The quadrurates, on the other hand, are especially the physiological salts of uric acid. They constitute the exclusive combination in which uric acid exists in solution in normal urine, and they become visible sometimes as the amorphous urates sediment.

"The special characteristic reaction of the quadrurates is that they are immediately decomposed by water into free uric acid and biurates" (see *Halliburton*).]

Urate of Soda. Acid Sodium Urate.

(Plates V., VII., IX., XI., and XXVII.)

Acid sodium urate, which is a product of the double decomposition of neutral sodium urate and acid sodium phosphate,* forms the principal constituent of the lateritious sediment, where it is associated with the corresponding compounds of

* Regarding this point see general remarks on *Urates*, p. 32.

potassium, calcium, and magnesium. This sediment, which is frequently deposited from concentrated urines, on cooling, is variously coloured by uroerythrin and urobilin; generally it has a reddish colour, either cochineal red, flesh red, or brick red; more rarely it has a clay colour, or is yellow, brownish- or greyish-yellow (Plate IX., Fig. 2; Plate XI., Fig. 4).

Deposits of urates are met with, particularly in febrile diseases, in cases where the system is robbed of large quantities of water (profuse sweating, profuse diarrhœa) in passive renal congestion, after a febrile crisis ["critical urates"—it is well to remember that uratic deposits in the urine of fever patients do not always indicate a crisis], and in healthy individuals after severe physical exercise and the ingestion of large quantities of animal food.

Amorphous urates occur in acid urines and consist of very fine amorphous masses or granules, variously coloured by the urinary pigments which are thrown down with them. These granules are arranged together in minute clumps, chains, or dendritic masses (Plate V., Fig. 6; Plate VII., Fig. 2); the individual granules appear almost colourless, and it is only when seen in dense masses that they show their characteristic colour. [Amorphous urates are often precipitated on the surface of bacteria.] When deposited on threads of mucus, they may form cylindrical structures which may be mistaken for granular casts (pseudo casts). [A slight lateral displacement of the cover glass frequently rolls the mucus and urates into cylinders, the nature of which is readily made out, owing to the fact that all these "cylinders" are straight and parallel to each other.] Urates may also be deposited in or on the surface of true casts and epithelial cells, particularly in acute nephritis (Plate XXVII., Fig. 1), when they give these structures a granular appearance. By the addition of hydrochloric acid the nature of the granules may be easily ascertained.

Along with the amorphous urate granules one frequently observes in the upper layers of the sediment, specially in urines which have stood for some considerable time, scattered crystals of uric acid, which may be visible to the unaided eye (Plate XI., Fig. 4), and are not dissolved by heating.

Uric acid and urates also occur together during the acid fermentation of the urine, in febrile urines, in leukaemia, and in cases where there is a disposition to calculus formation.

On the occurrence of alkaline fermentation, the sodium urate is replaced by acid ammonium urate [and earthy urates.]

Very rarely, acid sodium urate occurs in the form of acicular crystals arranged in sheaves or rosettes (Plate IX. in Ultzmann and Hofmann's *Atlas der Harnsedimente.*)

Acid sodium urate is readily dissolved by heating the urine (to the body temperature) or by the addition of dilute caustic potash; in the latter case, a separation of phosphates occurs after a short time; if hydrochloric or acetic acid be added to the solution, crystals of uric acid are deposited in from quarter to half an hour.

The amorphous earthy phosphates present microscopical appearances similar to those of the amorphous urates, but the phosphatic granules are, as a rule, whiter in colour, larger, and more closely packed together; they also are not affected by heating, and are dissolved by acetic acid and other acids.

In the kidneys of newly-born children crystalline deposits of urates, specially acid

ammonium urate, may occur and these deposits may pass into the urine, where they are found under the form of spheroids united into cast-like masses, frequently associated with amorphous urates, and of casts composed of deeply coloured spherules of ammonium urates (Plate XVI., Fig. 3, and the section on *Ammonium urate casts*, p. 72).

In tophi, acid sodium urate is met with in the form of numerous amorphous granules scattered amidst the fine needles of uric acid (see Plate VII., Fig. 1, and the section on *Uric acid in tophi*, p. 31).

[The amorphous precipitate generally described under the name of acid urate of sodium is really a mixture of urates in which the acid is distributed in various proportions among several bases, the most important of which are potash, soda, and ammonia, but traces of urates of magnesium and calcium are not unfrequent, and in disease the latter salts may become somewhat important. Urate of sodium, possibly impure, is not always amorphous, it may form spheroidal masses, covered or not with spicules: it is difficult to determine exactly the composition of a scanty sediment of urates mixed with other products, and statements based only on microscopic appearances and solubility tests are not to be considered conclusive.]

Urate of Ammonia. Acid Ammonium Urate.

(Plates II., VII., VIII., XVI., and XXII.)

This urate is found in alkaline urine—in neutral or acid urine it is but rarely met with; it occurs very frequently during ammoniacal fermentation of normal urine and is then (Plate XXII., Fig. 2) associated with crystals of triple phosphate and deposits of earthy phosphates and carbonates; it is also found in cases of cystitis in which the urine has undergone ammoniacal fermentation in the bladder, in the uratic infarcts of the new born, forming in the latter case the so-called *ammonium urate casts* (see Plate XVI., Fig. 3, and the section on *Casts*, p. 72); lastly, ammonium urate occurs as a constituent of vesical and renal calculi, particularly in children, where the calculus may be composed entirely of ammonium urate.

Acid ammonium urate crystallises in the form of opaque yellowish-brown or greyish-yellow spheroids (Plate II., Fig. 1; Plate VIII., Figs. 1 and 2), which frequently present radiating peripheral processes or spines giving rise to the so-called "thorn-apple," "hedgehog," stellate (Plate VIII., Fig. 3), or "rhizome" varieties (Plate VII., Fig. 6); the latter are especially met with when alkaline fermentation occurs rapidly in freshly voided urines of neutral or acid reaction.

As a rule, the number of spines is not great; occasionally, however, the whole surface of the spheroid is covered with numerous fine points arranged like the spines of a sea urchin (Plate VIII., Figs. 1 and 3). Not unfrequently the spheroids are arranged in pairs (Plate VII., Fig. 3 and 4) or are aggregated into large groups and coherent masses (Plate VIII., Fig. 2). They may present one or more elongated spines which cause them to resemble minute turnips, molar teeth, &c., &c. (Plate VII., Fig. 6).

Acid ammonium urate occurs rarely in the form of colourless or yellowish, highly refractive needles and prisms (see Plate XXII., Fig. 2, and the section on *Alkaline fermentation of the urine*, pp. 76 and 89).

In old urines (sometimes forming part of the crystalline pellicles which form on their surface) acid ammonium urate may be met with, along with calcium carbonate (amorphous and crystalline). It assumes then the form of fine needles which are either isolated or grouped together in the form of tufts, sheaves, or stars. [When such needles are found in a urine containing also a precipitate of carbonate of calcium it is possible, and even probable, that they are composed of urate of calcium.] They resemble closely crystals of ammonium urate artificially produced. Acid ammonium urate is dissolved on heating but separates again on cooling in the characteristic forms described above.

On the addition of hydrochloric or acetic acid the crystals dissolve and crystals of uric acid gradually appear. If it is treated with caustic potash, bubbles of ammonia are evolved. [This occurs only when very little water is present or when the urine is already saturated with ammonia.]

By these reactions the spheroids of acid ammonium urate are readily distinguished from those of leucin. Their size and colour suffice to distinguish them from the colourless spheroids of calcium carbonate, and, in doubtful cases, the nature of the urate will be shown by the murexide reaction, and that of the carbonate by the evolution of carbonic acid on the addition of a dilute acid.

[Urate of Magnesium.]

[Two forms of urate of magnesium are found in urine and calculi.

It is chiefly in connection with calculi that the urates of magnesium have been studied. The normal urate is of frequent occurrence; *Bigelow* has found the hydrated biurate of magnesium only twice in a series of several hundred analyses of calculi (*Robin*).]

[Urate of Calcium.]*

[Urine in which oxalate of lime (with, perhaps, an excess of uric acid) is present, sometimes contains small acicular crystals, differing both from oxalate of lime and from any of the generally known urates. Crystals of this kind have been found by the editor in the urine of two gouty subjects (Fig. 6).

Crystals of uric acid and natural sediments of acid urates, when allowed to stand in hard water, or in lime-water, for some time, undergo various changes, being ultimately replaced by small masses of colourless acicular crystals (Fig. 8), comparatively insoluble in cold and hot water. These alterations do not occur when distilled water is used instead of hard water.

Urate of calcium, on account of its slight solubility, has a tendency to precipitate whenever uric acid is present in a solution containing less insoluble compounds of calcium.

This salt is mentioned and partly described in several works, *Heintz* being the chief authority on the subject. *Neubauer* and *Vogel*, *Parkes*, *Beale*, *Bouchut*, &c., either repeat what Heintz says on urate of calcium or simply mention it in a very casual fashion.

[* S. Delépine, *Proceedings of the Physiological Society*, 1887.]

Urate of lime is colourless, or white when seen in large quantities; it occurs both as an amorphous and as a crytalline precipitate, and in the latter case it forms long needle-shaped crystals generally grouped together as shown in the figures; it is much less soluble in hot water than the ordinary forms of urates, and is less easily decomposed by acids; a strong acid displaces the uric acid, which crystallises readily; when sulphuric acid is used, sulphate of lime crystals are also precipitated, and in that case irregular forms, such as dumb-bell crystals, of uric acid (?) are often produced. The murexide reaction is easily obtained.

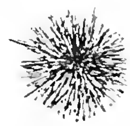


Fig. 6.—Urate of Calcium (× 160). From the urine of a gouty patient.

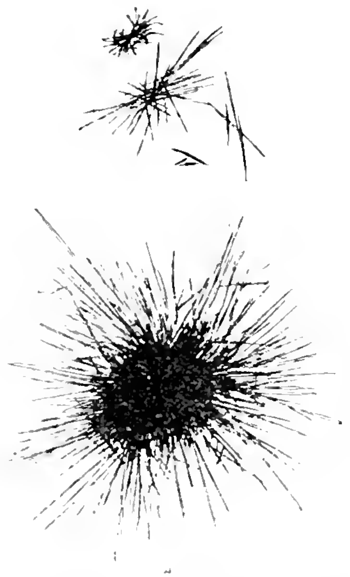


Fig. 7.—Urate of Calcium (× 160). Prepared by addition of pure uric acid to a solution of pure hydrate of lime.

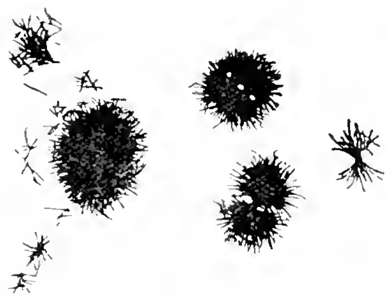


Fig. 8.—Urate of Calcium (× 160). Prepared by allowing uric acid precipitated from urine to remain for several days in a large excess of hard water (London water).

The appearance of these crystals is exactly the same as that of the so-called crystals of urate of sodium found in the gouty deposits which often impregnate the cartilages and ligaments of gouty patients.

When these acicular crystals are treated with sulphuric acid, a double precipitate of uric acid and sulphate of calcium is usually obtained. The presence of other salts may complicate this reaction.

There are two forms of urate of calcium, one an acid salt, comparatively soluble in water; the other, a normal salt, comparatively insoluble. This it will be remembered is just the reverse of what obtains in the case of the alkaline urates.

See also section on *Uric Acid* and *Uric Acid Salts in Tophi* (p. 31).]

Hippuric Acid.

(Plate XII.)

This substance exists in small quantities in human urine, it is usually in solution, and very rarely forms a sediment.

[It is not free in normal urine, but is combined with various bases forming alkaline and earthy hippurates.]

After the ingestion of large quantities of vegetables, particularly of fruits containing benzoic acid (cow-berries, pears, plums, bilberries, greengages, &c.), and also after the internal administration of aromatic acids (benzoic acid, salicylic acid, cinnamic acid), the amount of hippuric acid in the urine is considerably increased, notwithstanding which it rarely forms a precipitate.

It occasionally appears as a crystalline sediment in diabetes, jaundice, liver diseases, and in febrile urines of acid reaction. It is much more frequently observed in the tropics. The pathognomonic significance of hippuric acid is unknown.

It crystallises in the form of colourless needles, rhombic plates (Plate XII., Fig. 1), and four-sided prisms, which are terminated by two or four oblique surfaces (the fundamental form is a vertical rhomboid prism).

The prisms and needles are sometimes set to one another at acute angles, so that irregular and stellate groups are formed. [Hippuric acid is slightly soluble in cold water and alcohol, but is readily dissolved by those fluids when they are hot.] It does not give the murexide reaction. It is thus easily distinguished from abnormal uric acid. Crystals of "neutral" calcium phosphate and ammonio-magnesian phosphate assume at times the form of four-sided prisms like those of hippuric acid, but the insolubility of the latter in acetic acid and its solubility in alcohol render distinction easy.

Cystin.

(Plates VIII. and XII.)

Cystin exists in normal urine merely in traces. When it occurs in abnormal quantity, either in solution or as a sediment, the presence of cystin calculi in the urinary passages may be suspected. It is a nitrogenous body, the product of some perversion of normal metabolism. Cystin contains sulphur, hence sulphuretted hydrogen is frequently formed when urine containing this substance undergoes decomposition.

It occurs in acid or slightly alkaline urines; in the latter it is associated with deposits of amorphous and crystalline earthy phosphates [sediments of cystin gradually disappear when the urine becomes ammoniacal.] Urine containing a large amount of cystin is generally pale and very apt to undergo alkaline fermentation.

Cystin crystallises in characteristic thin, colourless, more or less regular hexagonal plates, which are frequently imbricated, in this way large crystalline masses are often produced (Plate VIII., Fig. 4; Plate XII., Fig. 2).

The crystals are insoluble in water (even boiling), alcohol, ether, [acetic and tartaric acids]; they are rapidly dissolved by ammonia, the caustic alkalies, and the mineral acids. (The hexagonal plates of uric acid, which have some resemblance to cystin, dissolve slowly in ammonia.) From ammoniacal solution cystin separates out in hexagonal plates on evaporation of the ammonia or on the addition of acetic acid. It does not give the murexide reaction.

Cystin is readily distinguished from flakes of dicalcium phosphate by its crystalline form and its insolubility in acetic acid.

Plate VIII., Fig. 4, was taken from a case of cystinuria, with cystic calculus and pyelitis. This case presented the following features:—

A fairly well-nourished man, aged 25 years, otherwise healthy, had suffered for several weeks from violent renal colic; this gradually disappeared without treatment. No other member of his family had ever been affected in the same way. The urine was taken at a time when a hard, smooth, yellowish cystin calculus of the size of a pea had just been passed, during an attack of colic; it had a slightly acid reaction, a pale greenish-yellow colour, and deposited a greyish-white sediment consisting of cystin crystals, red and white blood-corpuscles, many of the latter showing amœboid movements, crystals of ammonio-magnesian phosphate and amorphous earthy phosphates.

[Cystinuria may exist without any evidence of disease other than the presence of cystin in the urine. Normally, in the course of the formation of sulphuric acid products, a substance akin to cystin ($C_3H_6NSO_2$) (*Baumann*)—namely, cystein ($C_3H_7NOSO_2$)—is formed; the formation of cystin from cystein apparently does not take place normally, but may do so under circumstances which are not understood yet (see *Halliburton*).

The editor had, in 1889, the opportunity of making several observations on a case of cystinuria which was under the care of Dr. Lauder Brunton. The patient was a middle-aged man, and had on a previous occasion been relieved of a cystin calculus. At the time he came under observation he had no symptom of stone formation. The following table is a statement of the results of four examinations of the urine.

During the investigation several facts of interest were observed. Thus—(1) When specimens were *strongly acidified with acetic acid*, as recommended by *Löbisch*, the precipitation took place more slowly than if the specimens were allowed to undergo a *spontaneous acid fermentation* (which never caused the reaction to become very strongly acid). (2) When the fluid was *carefully filtered*, the precipitation of cystin was delayed, often for several days. (3) When a specimen in which cystin had begun to separate was *carefully filtered*, the precipitation was interrupted for a time. (4) When a certain quantity of the urine was left under conditions allowing rapid multiplication of microbes, and an equal quantity of the same fluid was kept at a temperature of about 60° C., it was found that, whilst cystin crystals appeared rapidly in the first specimen, none could be obtained from the second, even on evaporation or addition of acetic acid. (5) Evaporation did not seem to increase materially the amount of cystin obtainable from a given specimen, though it accelerated its separation. (6) The

	March 5.			April 29.
	I.—Just before luncheon.	II.—One hour after luncheon.	III.—Four hours after luncheon.	Urine passed in 24 hours from April 28 to April 29.
Total quantity in 24 hours,	...	...	...	1525 c.c.
Colour, ...	Pale reddish-yellow.	As I.	As I. and II.	Pale greenish-yellow.
Sediment, ...	After 24 hours, nubecular in character—*i.e.*, bulky, whitish, translucent, flocculent, diffusible.			
Smell, ...	Aromatic, distantly analogous to that of sweet briar and dried leaves.			
Specific gravity, . .	1018	1019	1018	1021
Reaction, ...	Faintly alkaline.	Feebly acid.	Very feebly alkaline.	Almost neutral, feebly alkaline.
Albumen, ...	0	0	0	0
Glucose reaction,	No excess.	No excess.	No excess.	No excess.
Urea, ...	1·39 per cent.	1·6 per cent.	1·38 per cent.	1·4 per cent
Indican reaction, .	0	0	0	0
Sulphur reaction, (Acetate of lead, . Potash, heat), .	Brown colour well marked in each specimen examined.			
Cystin estimated by Löbish's method (precipitation by acetic acid),	0·195 $^0/_{00}$	0·375 $^0/_{00}$	0·175 $^0/_{00}$	0·522 $^0/_{00}$
Quantity in 24 hours, .	...	...	...	0·7958 gramme.
Mic. examination, immediately after urine voided,	No typical crystals; a few irregular crystalline masses, not cystin.	A few typical crystals of cystin; the rest as in I.	The same as I.	No typical crystals of cystin. A few irregular crystalline looking masses, not cystin; a few cylindroids and renal epithelial cells.
After 24 hours, . .	No cystin.	Amorphous urates and a few crystals of cystin.	No cystin.	...
After standing 7 hours without addition of acid,	(Fluid faintly acid.) Cystin crystals small and scanty. Bacteria, yeast, and mould abundant.	(Fluid acid.) Urates. Typical crystals of cystin abundant. Bacteria and yeast abundant.	(Fluid faintly acid.) Cystin scanty. Bacteria, yeast, and mould abundant.	(Fluid acid.) Typical large crystals of cystin abundant. Bacteria, yeast, and mould.
After 6 days, . .	...	...	...	Ammoniacal fermentation. Reaction alkaline. Sulphide of ammonium. Triple phosphate. Crystals of cystin have disappeared.

largest amounts of cystin could be obtained by allowing *the specimens to stand at the ordinary temperature for several days,* provided the precipitate was separated *whilst the urine was still acid.* (7) A similar amount of cystin could be obtained more rapidly by keeping the fluid at a *temperature higher than the normal, but*

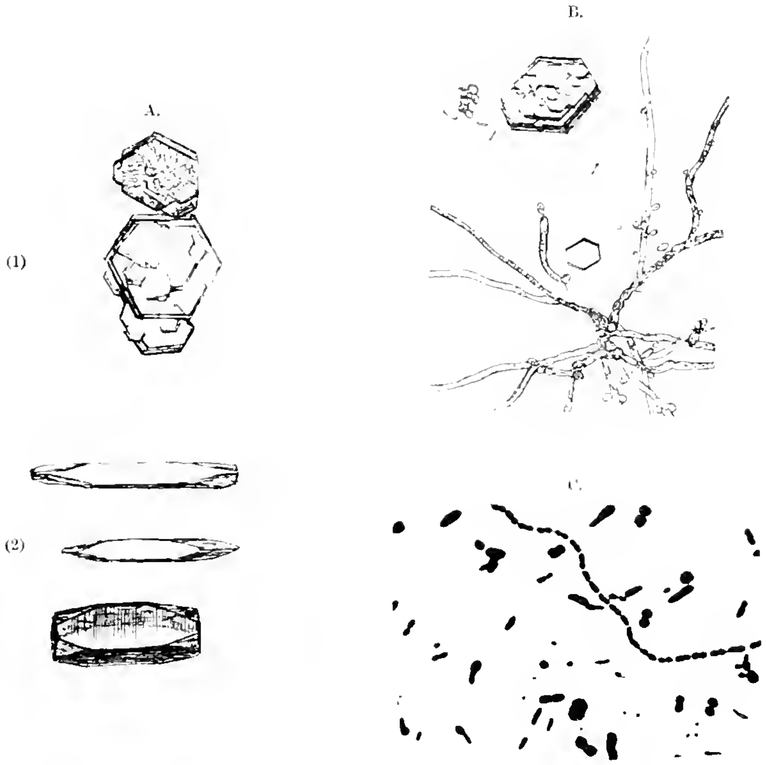


Fig. 9.

EXPLANATION OF FIGURE.

Fig. 9, A. (1).—Cystin spontaneously deposited from the urine of a patient affected with a cystic calculus.

(2).—Cystin, reprecipitated by addition of acetic acid after previous solution in ammonia.

Unusual form, indicating the derivation of the hexagonal plates from a straight prism with a square base ($\times$ 160).

Fig. 9, B.—Urinary sediment in a case of cystinuria, in addition to the crystals of cystin, part of a group of mycelial looking filaments is represented. Many of the filaments are composed of oval elements, some of which are budding. There were also a few renal cells not shown in the drawing ($\times$ 160).

Fig. 9, C.—Bacteria and yeasts, found in the urine of the case mentioned in the text. After the urine had been allowed to stand 120 hours, hexagonal plates of cystin had deposited in great abundance. The organisms are stained with an aqueous solution of gentian violet, the envelopes of the yeast cells are not stained ($\times$ 1200).]

below 40° C., for twenty-four to thirty-six hours. (8) When a drop of urine from which cystin was being deposited was added to a portion of the same urine carefully filtered, a deposit of cystin occurred in twenty-four hours, while another portion of the filtrate, protected from organisms, deposited no cystin for ninety-six hours. From all these facts it may be surmised—

1. That the *simple* addition of an acid in which cystin is not soluble is not sufficient to separate cystin from the urine.

2. That a compound exists in *certain* urines which under *the influence of fermentation yields* cystin.

3. That the fermentation is due to the *growth of an organism*, which can apparently be separated from the urine by filtration through filter paper, and must, therefore, be a *large organism, probably one of the blastomycetes.*

4. That the cases recorded in which cystin has been found deposited in the kidneys and liver indicate that the *separation may begin in the system* (whether owing to the action of an organised or of an unorganised ferment, cannot be determined on the basis of the facts in our possession).] *

Leucin and Tyrosin.

(Plate VIII.)

These substances do not occur in the urine under normal conditions, they are both products of the decomposition of proteids, and their presence always indicates very considerable disturbances of metabolism.

They are most frequently met with in cases of acute yellow atrophy of the liver and of phosphorus poisoning; they occur occasionally in typhoid fever, smallpox, and in certain blood diseases, such as pernicious anæmia and leukæmia. Leucin and tyrosin generally occur together in the urine, the latter being, as a rule, much more abundant than the former. They form a distinct greenish-yellow sediment only in those cases in which they are present in considerable quantity, as in acute yellow atrophy of the liver.

Tyrosin, being but slightly soluble, separates out readily, but the separation of leucin, which is much more soluble, may occur only after the urine has been evaporated to a syrupy consistence or not until after the addition of alcohol to the concentrated fluid and further evaporation; as a rule, the slow evaporation of a drop of urine on a slide is sufficient for their demonstration.

Tyrosin crystals may be obtained in a purer form by a method recommended by *Frerichs.* If the fluid is albuminous, the proteids are first precipitated by boiling; the pigments and extractives are precipitated by the addition of basic lead acetate, the excess of lead in the filtrate is got rid of by means of sulphuretted hydrogen, the lead sulphide is removed by filtration, and the clear fluid is evaporated down. Crystals obtained in this way differ from those found in freshly voided urine in being colourless.

Tyrosin crystallises in the form of very fine silky needles, which are either colourless or of a yellowish, greenish, or brownish colour, owing to the presence of some

[* S. Delépine, *Proceedings of the Royal Society*, vol. xlvii., 1890.]

pigment (Plate VIII., Fig. 5); they are rarely isolated, but generally arranged in a radiating fashion in the form of sheaves, rosettes, or brush-like tufts.

Tyrosin is soluble in hot water, but more readily in ammonia, caustic potash, and dilute hydrochloric and nitric acids, it is slightly soluble in acetic acid, and is insoluble in alcohol and ether.

Hofmann's reaction affords a valuable means for the recognition of tyrosin apart from its crystalline form.

The material is heated in a test tube with a little water, and to the hot solution a few drops of Millon's reagent are added: the fluid assumes a rose or purplish-red colour; when much tyrosin is present it yields an abundant red flocculent precipitate.

The following reaction is also useful although not so sensitive as the above: the suspected material is gently warmed in a porcelain capsule with a few drops of concentrated sulphuric acid, tyrosin when present dissolves with a transitory deep red colour:—

[*Piria's Reaction.*—A milligramme of the crystalline precipitate, separated by filtration, is placed in a watch-glass and moistened with a drop or two of strong sulphuric acid. The mixture is covered and allowed to stand for half an hour. It is then diluted with water, heated, and, while still hot, saturated with carbonate of calcium. When the effervescence has ceased, the fluid is filtered. To the colourless filtrate some acid-free ferric chloride is added; the presence of tyrosin is indicated by a violet colouration (see *v. Jaksch*).]

The possibility of confusing tyrosin crystals with those of neutral calcium phosphate (Plate II., Fig. 5) and their differentiation has already been considered in the section relating to the phosphates. To distinguish tyrosin from uric acid, crystallised urates, or fatty acid needles the chemical reactions given for each of these substances may be used.

Leucin crystallises in the form of faintly glistening, yellowish spheroids, some of which, especially the larger, present fine radial and circular striations (Plate VIII., Fig. 5) resembling the markings on the cross section of the trunk of a tree. [These markings indicate the structure of the spheres, which are made up of acicular crystals, radiating from the centre.] Not infrequently several small colourless or faintly coloured spheroids may be seen adhering to the surface of larger spheroids.

Sometimes the masses have an oval form, especially when arranged together in groups (Plate VIII., Fig. 6).

Leucin is readily soluble in acids and alkalies; its spheroids may be differentiated from those of *acid ammonium urate by their structure* (concentric and radial striation) and colour [when these are distinct, which is seldom the case in recently prepared specimens], by the absence of peripheral spines, by their larger size, and by the absence of any tendency to form pairs. On the addition of acetic acid to urates, uric acid crystals separate. From *fat* also, leucin may have to be distinguished; it refracts light less strongly than fat, it is insoluble in ether, and has a yellowish green colour in fresh urine.

Cholesterin.

(Plates XI., and XII.)

This substance is sometimes met with as a urinary sediment in lipuria, in lardaceous and fatty degeneration of the kidneys, in nephrolithiasis, in hydatid disease of the kidneys and in cystitis.

It crystallises in thin, transparent, rhomboid plates of varying size (often imbricated and united to one another; Plate XII., Fig. 3). These plates frequently present rhomboid notches at one angle, sometimes giving rise to a step-like appearance.

The crystals are readily soluble in ether, hot alcohol [and chloroform], but are insoluble in water, alkalies, and acids. When treated with warm sulphuric acid the crystals are gradually eroded from the periphery to the centre, the process of solution being preceded by the appearance of a reddish-brown zone. The addition of iodine (Lugol's solution) and concentrated sulphuric acid causes the crystals to assume in succession yellow, yellowish-red, pink, violet, green, and blue colours; the multicoloured crystals giving to the preparations a kaleidoscopic appearance (Plate XI., Fig. 5).

[In one case only (out of more than 4000 examined) has the editor found *crystallised* cholesterin sufficiently abundant in the urine to attract his attention. The urine was slightly alkaline, had a brownish-yellow colour and its specific gravity was 1025. It contained 1·2 per cent. of urea, gave a marked biuret reaction, and was found to contain a large amount of a mixture of various albumoses. After death it was found that the right kidney was in the state usually described under the name of *congenital or fœtal cystic kidney*.

The ureter was patent and several cysts with thin walls projected into the renal pelvis; it is probable that the occasional appearance of cholesterin and albumoses in the urine was due to the bursting of one of these cysts, or, possibly, to the escape of the contents in some other way. The fluid in several of the cysts was found to contain cholesterin, albumoses, and 1 per cent. of urea.]

Xanthin.

Xanthin may occur as a precipitate in the urine, and has been found associated with the presence of xanthin calculi [*Marcet* and *Bence-Jones'* case]. The causes which lead to increased formation of this substance in the organism are as yet unknown.

[Xanthin is normally present in small amount in the urine (*Strecker*), but, as a urinary sediment, is of extreme rarity. It is closely related to uric acid.]

It crystallises in the form of small colourless rhombic plates (whetstone forms) of fairly uniform size.

Crystals of uric acid, when they are pale, may be mistaken for xanthin crystals, but the latter dissolve on heating the urine, or in warm water, and are very readily soluble in dilute ammonia; they are insoluble in acetic acid, and do not give the murexide

reaction. (When a drop of nitric acid is added to xanthin and then evaporated to dryness, a yellow residue remains, but this does not become red or purple on the addition of ammonia.)

[In the presence of a small amount of a chloride, xanthin gives the murexide reaction. In *Weidel's* test, which is almost identical with the murexide test, chlorine water is used instead of nitric acid (*F. Gowland Hopkins*, in *Schäfer's "Physiology."*). Figures of xanthin crystals are given by *Bence-Jones* (*Journ. of the Chem. Soc.*, London, 1862), and in many text books.]

Fat.

(Plates XII., XV., XXVIII., XXIX., XXXII., XXXIII., XXXV., and XXXVI.)

Fat is sometimes met with in the urine (**lipuria**) after the ingestion of large quantities of fatty substances (*e.g.*, cod-liver oil, &c.); it is, however, more especially met with in tropical **chyluria** due to *Filaria sanguinis hominis*. [Chyluria may also be produced by obstruction of the chyle vessels independently of the presence of the filaria.] In this condition the fat is suspended in the urine in the form of an emulsion in which the fat is very finely divided, and it is only after the milky albuminous urine has stood for some time that a creamy layer separates on its surface.

Fat globules, either free or contained in granule cells, also occur in other diseased states. Thus small quantities of it are frequently observed in chronic nephritis, specially in cases where there are marked fatty changes in the renal epithelium and other cell elements (large white kidney); the globules may be free or enclosed in casts, leucocytes, and epithelial cells (Plate XXIX., Fig. 2; Plate XXXII., Fig. 2; Plate XXXIII., Fig. 2). Fat globules are also met with in cases of cystitis, diabetes mellitus, and, particularly, acute phosphorus poisoning, where extensive fatty degeneration and disintegration of cells occurs. [*Ebstein* has recorded a case of pyonephrosis in which a large amount of fat was found in the urine.]

In examining urine for fat it should not be forgotten that it may be present as an accidental contamination—*e.g.*, owing to unclean vessels, catheters, &c. (see section on *Accidental Contaminations of the Urinary Sediment*, p. 87, and Fig. 3, Plate XXXV.). The fat globules vary very considerably in size and possess high refractive powers (Plate XV., Figs. 1 and 2; Plate XXXV., Fig. 3); they become black after treatment with a $\frac{1}{4}$ to 1 per cent. solution of osmic acid (Plate XXXIII., Fig. 1; Plate XXXV., Fig. 1). On heating, the familiar penetrating odour of acrolein may be detected. Fat globules are soluble in ether and produce the characteristic grease spot on paper.

Since osmic acid blackens other substances than fat, "*Sudan III.*" may prove a more reliable agent for fat. (This reagent was first recommended by *Daddi* of Turin.) This substance (in alcoholic solution) stains fat alone, and gives to it a colour varying between orange and scarlet (Plate XXXIII., Fig. 2). *

* ["Sudan III." is a disazo-body of the formula $C_{22}H_{16}N_4O$; it has a brick-red colour, is soluble in alcohol, xylol, ether, &c., and is insoluble in water and glycerine. Daddi of Turin, in 1896, used it in feeding experiments. Dr. Rieder has applied it with success to histological work. (*Deutsches Archiv f. klin Med.*, December, 1897.) See also Nicholls, *Montreal Med. Journ.*, June, 1898.]

Sometimes the fatty acids [or rather **soaps of lime and magnesia**] occur in the urine in the form of delicate acicular crystals often slightly curved (Plate XII., Fig. 4; Plate XV., Fig. 1; Plate XXVIII., Fig. 2; Plate XXXVI., Fig. 1); these are occasionally aggregated into tufts and stars. Isolated needles may be readily distinguished from large bacteria by treating the specimen with methylene blue or several other basic aniline dyes which stain the fungi and not the fatty needles.

It should be borne in mind that similar needles may be conveyed to the urine in the vaginal mucus.

[These crystals are chiefly derived from the *smegma* which accumulates, at times in large quantities, under the prepuce in the male, and between the folds of the vulva in the female.]

Uroerythrin.

This is the most common of the pigments met with in the urine; to it the deposits of uric acid and urates owe their pink or red colour (see section on *Amorphous urates*, p. 34).

Blood Pigment.

(Plate XIX.)

Blood pigment may be present in the urine, either free or contained in casts (blood pigment casts); it varies in colour from yellowish-red to brownish-black. Blood pigment casts are met with in cases of hæmorrhagic nephritis, hæmorrhagic infarction of the kidneys, and in hæmoglobinuria; free blood pigment may, on the other hand, be found in all forms of hæmaturia and in the urine of menstruating females. It occurs either in solution or in the form of a fine or coarsely granular deposit, which may be free or enclosed in cells and casts, or it may have the form of irregular brownish-yellow scales of varying size (Plate XIX., Fig. 5).

In hæmoglobinuria it is present in large quantities. In addition to this iron-containing pigment or **hæmosiderin,** iron-free hæmatoidin crystals are occasionally met with in the urine; these have the form of rhombic plates and needles.

[To be of any use, the consideration of the blood pigments which occur in the urine must include both the soluble and the insoluble forms. So many products may be stained by the soluble pigments that these, as well as the insoluble forms, may be said to enter into the composition of sediments. The following account taken from *Halliburton* is perhaps the clearest that may be given of the subject without entering into very complex questions:—

"**Methæmoglobin** is generally formed in small quantities in acid urine which contains blood after its removal from the body. In other cases, the pigment occurs in a condition more akin to **hæmatin** than to **hæmoglobin.** In some cases, very little of the blood passed dissolves in the urine; the most characteristic spectrum which is then obtainable from the deposit is that of **hæmochromogen.**

. . . Blood pigment may, under certain circumstances, appear in the urine without the presence of any blood-corpuscles whatever. That this was the case was first shown by *Pavy*. (This condition is known as **hæmoglobinuria** or **methæmoglobinuria**.) Sometimes brown masses composed of granular pigment, looking like casts as if they were moulded in the urinary tubules, are seen in these cases. This condition is produced by a destruction of blood-corpuscles in the circulation," and may occur as a result of various diseases (pyæmia, typhus, scurvy, fat embolism, severe burns, some cases of jaundice, &c.), or of various forms of poisoning (arseniuretted hydrogen, hydrochloric, sulphuric, carbolic, and pyrogallic acids, phosphorus, potassium chlorate, &c.).

Oxyhæmoglobin crystals have been found in one case of paroxysmal hæmoglobinuria (*Neale*); but the pigment most commonly present is methæmoglobin (*Hoppe-Seyler* and *MacMunn*), and as it is the only pigment present in many cases, Hoppe-Seyler has suggested the name of methæmoglobinuria as being more correct than the usual term. *Halliburton*, however, has found that oxyhæmoglobin was more frequently present than Hoppe-Seyler believed.

The editor has found amorphous granules, having the characters of hæmatin, alone or mixed with crystals of hæmatoidin, in several small calculi passed during life. In one case there were symptoms of renal colic, with occasional hæmorrhage, and small concretions composed of oxalate of calcium, phosphate of calcium, and hæmatoidin, loosely held together, were passed from time to time.

In another case, in which there was tumour of the bladder, with frequent hæmorrhage, a small calculus was found once in the urine; this calculus was composed of a shell of phosphates and urates, with a soft granular centre, in which typical crystals of hæmatoidin were moderately abundant; both these cases show clearly how small clots may act as nuclei for calculi.]

Melanin.

Melanin occurs in the urine in the form of black or dark brown granules in cases of melanæmia (a very rare condition) and of melanotic tumours; the pigment granules may occur free, scattered about or united into groups, or they may be enclosed in cells, especially leucocytes, but sometimes also epithelial cells and casts.

In such cases the urine is either of a dark colour when voided, and on standing deposits the above pigment; or it may be pale at first and become darker after some time (in consequence of the conversion of melanogen into melanin), or after the addition of some oxidising agent (chromic acid, nitric acid).

[Urines which become dark owing to the presence of melanin have seldom a dark colour when passed; the pigment may become apparent very rapidly after micturition, but even in those cases the colouration does not attain at once its full intensity. This seems to be the result of a gradual oxidation of a chromogen to which the name "melanogen" has been given. The production of the dark pigment may be obtained usually at once by addition of hydrochloric, sulphuric, nitric acids, or of ferric chloride.

Von Jaksch, who has made a special study of this substance, says that the best reagent to detect melanogen is a very dilute solution of ferric chloride, which gives, when that substance is present in the urine, a black precipitate.

The pigment in melanuria is generally held in solution, and seldom forms a granular precipitate.

The practical significance of this condition is greatly limited by the fact that the urine of patients affected with wasting diseases may contain a large quantity of melanin, whilst that of patients suffering from melanotic tumours may be entirely free from it (*von Jaksch*). The editor has observed melanuria in two cases in which there were large degenerating, but non-pigmented tumours.

Nevertheless, the existence of melanuria should always suggest the possibility of the existence of a melanotic tumour.

Melanæmia seems to have, usually, an origiu quite different from that of melanuria. In a case of melanuria studied by *Mörner*, the blood was found normal.]

Bilirubin (Hæmatoidin) Crystals.

(Plates IX., X., and XXVIII.)

The bile pigment "bilirubin" has the same characters and the same chemical composition as that derivative of hæmoglobin termed "hæmatoidin."

It is occasionally found in the urine in a crystalline form, and is of more common occurrence than was formerly supposed.

It is met with in cases of vesical cancer along with, and contained in, necrotic shreds and carcinomatous villi (Plate IX., Fig. 1); in cases of acute nephritis, renal abscess, after renal hæmorrhage, in infectious diseases, in intoxications (particularly phosphorus poisoning); in the severe jaundice of adults due to catarrhal angiocholitis (Plate XXVIII., Fig. 2), in carcinoma of the liver, in acute yellow atrophy; after the transfusion of alien blood; and, lastly, in cases of icterus neonatorum.

[The presence of these crystals in the urine frequently indicates the probability of some extravasation of blood or the bursting of an abscess into the urinary passages.]

The crystals usually have the form of fine needles (Plate IX., Fig. 1; Plate X., Figs. 2, 3, and 4), which may be arranged in tufts; they rarely assume the form of rhombic plates and oblique rhombic prisms. They vary in colour, being brownish-yellow, reddish-brown, or reddish-yellow (brick-red or carrot colour). They are frequently found attached to the cellular constituents of the sediment (leucocytes, epithelial cells), upon which they may lie isolated, crossed or arranged in tufts and stars, the centres of which often correspond with those of the cells. Not infrequently the crystals, single or grouped, are free in the fluid; in such cases the needles may appear slightly curved.

In addition to the crystals, amorphous pigment granules (derivatives of bilirubin) and scales of various colours may also be present; they are produced by oxidation of

the pigments after exposure of the urine to the air. The granules are generally contained in cells from the urinary passages.

Bilirubin (hæmatoidin) is [slightly] soluble in [alcohol] and ether, [readily soluble] in benzole, chloroform, carbon disulphide [and amyl alcohol]; it is also soluble in acids and alkalies, and gives Gmelin's reaction. (See also remarks on *Blood pigment*, p. 46.)

Figs. 2, 3, and 4 on Plate X. were taken from the urine of two icteric patients; one suffering from severe catarrhal jaundice, the other from carcinoma of the liver.

Indigo.

(Plates XI. and XVIII.)

Indican occurs only in small quantities in normal urine; it may, however, become abundant in certain morbid conditions of the alimentary canal, especially obstruction of the small intestine; it may also be increased when putrid products accumulate in any part of the body. In those cases it is evidently associated with an increased production of indol due to the putrefaction of albuminous substances taking place in the intestine or elsewhere.

[Increased excretion of indican has also been observed in cases of peritonitis typhus, carcinoma, Addison's disease, &c. The administration of certain aromatic drugs—such as turpentine, oil of bitter almonds, creasote—produces the same effect (see *Halliburton*).]

When an excess of indican is present in the urine this substance becomes transformed on exposure to air, especially during ammoniacal fermentation, into indigo-blue; the latter may be deposited either in the form of amorphous blue scales (Plate XI., Fig. 6), imperfectly formed rhombic or lanceolate crystals, or as stellate groups of acicular crystals. Indigo may also form a bluish pellicle on the surface of the urine. As the oxidation process, giving rise to the formation of indigo, is in progress, the urine becomes darker in colour.

By dissolving the amorphous deposit of indigo in chloroform and allowing the solution to evaporate slowly, blue rhombic crystals are obtained (Plate XVIII., Fig. 1). More rapid evaporation results in the formation of acicular crystals, which are also of a deep blue colour (Plate XVIII., Fig. 2).

The presence of urinary indigo may be recognised by the bluish colour which it imparts to the urine or sediment.

It is insoluble in water, almost insoluble in alcohol, but readily soluble in chloroform and benzole.

Indican is very rarely transformed into indigo in the organism; when this takes place in the urinary organs the urine has a blue colour when voided, and at once deposits crystals of indigo (**indiguria**).

Urinary indigo may be prepared artificially by adding hydrochloric acid to urine rich in indican, allowing it to stand for twenty-four hours, collecting the sediment on a filter, extracting with chloroform and crystallising.

[The tests usually employed for indican (or rather indoxyl-sulphate of potassium) are those devised by *Jaffé* and *MacMunn.*

Jaffé's Test.—Equal parts of hydrochloric acid and urine are mixed, and then a saturated solution of chlorinated lime is added, drop by drop, until the blue colour ceases to deepen.

MacMunn's Test.—Equal parts of urine and hydrochloric acid, with a few drops of nitric acid, are boiled together, and cooled.

In either case the indigo-blue produced is extracted by adding chloroform to the mixture and shaking thoroughly. After allowing the fluid to stand, the chloroform separates, having assumed a blue colour owing to the indigo which it has dissolved.

The editor has found that a small excess of *indigogen* is easily overlooked if either of these methods is used as indicated above. He prefers to mix the urine with a minute quantity of peroxide of hydrogen (about 1 part of H_2O_2, 10 vol. sol., to 100 parts of urine); to 1 part of this mixture, 1 part of hydrochloric acid is added. The fluid is then gently warmed, not boiled; if a deep blue colour is produced, more peroxide of hydrogen, or chlorinated lime solution, may be added cautiously, in order to obtain the complete transformation of the indigogen present. The indigo produced is extracted by chloroform, of which a proportion equal to about one-sixth of the total amount of fluid should be used. The crystals obtained by slow evaporation of the chloroform may affect the form of tetrahedra, and therefore seem to be derived from the cubic system; but they are also often prismatic. It is, therefore, probable that various forms of indigo are extracted during this process, or that indigo is precipitated together with some other substances.

By taking the precautions just described, it is easy to convince one's self that a small excess of indigogen is not infrequently present in the urine of patients affected with very slight disorders of the digestive organs.

The most marked instance of spontaneous precipitation of indigo observed by the editor was in a case of so-called "involution of the nervous system." The urine in that case was, when freshly voided, alkaline, it had a specific gravity of 1021, and contained a trace of albumen; there was a slight cloud due to precipitation of phosphates, but no distinct sediment. After twenty-four hours the urine, which was reddish-yellow at first, had become a little darker, and a thin pale bluish film with a coppery lustre, had formed on the surface.

That film under the microscope was found to be composed of large, irregular, angular, very thin phosphatic scales, with small, short, prismatic (some almost cubical) crystals, many of which were bright blue, others purplish-violet, and others still, colourless or almost colourless. A few of the crystals were acicular. One or two of the large prisms were facetted and terminated by straight pyramids.]

Nitrate of Urea.

(For the micro-chemical demonstration of urea.)

(Plate XII.)

Nitrate of urea does not occur in the urine; it is formed when a drop of pure concentrated nitric acid is added to concentrated urine or urine rich in urea.

Procedure.—Two or three drops of urine are placed on a clean slide, which is then cautiously moved to and fro over a flame until the fluid is so concentrated that a white ring forms at the periphery; after cooling, one or two drops of pure concentrated nitric acid are added, and the mixture is covered with a glass slip; crystals of nitrate of urea then appear within a few minutes in the neighbourhood of the white marginal ring; typical crystals of uric acid frequently form also in the centre of the preparation.

Another method consists in placing on a slide a drop of the fluid to be examined with a piece of cotton thread passing through its centre; the drop is then covered in such a way that the ends of the thread project beyond the edge of the cover glass, a small drop of concentrated nitric acid is placed at one end of the thread and allowed to flow under the cover glass, characteristic crystals soon make their appearance on both sides of the thread. Nitrate of urea (Plate XII., Fig. 5) crystallises in the form of hexagonal or rhomboid plates which are usually imbricated and form large groups. The crystals may be distinguished from the somewhat similar cystin crystals and from the hexagonal plates of uric acid by their solubility in water.

The above mentioned reaction may be of diagnostic value when acute yellow atrophy of the liver is suspected, since in this condition the urea almost entirely disappears from the urine; its place as a medium for the elimination of nitrogen being taken by leucin and tyrosin; it is also of value in testing fluids obtained by puncture of cysts which are suspected to be of hydronephrotic origin. The demonstration of uric acid in such fluids by the murexide reaction (see *Uric acid*) also confirms the diagnosis, but requires a longer time and a larger amount of fluid.

[It must, however, be remembered that only well-marked quantities of uric acid and urea would be pathognomonic of renal cysts, and that ovarian cysts may contain both urea and uric acid, and occasionally communicate with the urinary passages. On the other hand, both urea and uric acid may ultimately disappear from old renal cysts.]

Phenylglucosazon.

(Plate XVII.)

This substance is formed when diabetic urine is treated with phenyl-hydrazin hydrochloride and sodium acetate.

This characteristic and delicate reaction for the demonstration of glucose in urine is carried out as follows:—

Two grammes of phenyl-hydrazin hydrochloride and three grammes of sodium acetate are added to about 25 c.c. of albumen-free urine; the mixture is heated on a water-bath for half an hour and repeatedly shaken to effect the solution of the salts; at the end of this time it is rapidly cooled by placing the vessel in cold water. [The quantities given here are unnecessarily large—6 to 8 c.c. of urine are quite enough; the removal of albumen is not necessary, but advisable.]

The process may be simplified as follows:—

About two parts of phenyl-hydrazin hydrochloride and three of sodium acetate (the quantities may be measured with sufficient accuracy by being taken on the point of a knife) are dissolved in a test tube half filled with water; to the solution an equal volume of urine is added and the mixture treated as above.

In urine containing at least 0·05 per cent. of glucose, the phenyl-glucosazon forms a canary-coloured crystalline deposit. The precipitation of yellow crystals in abundance is characteristic of the presence of glucose.

Under the microscope the deposit is seen to consist of long, thin, yellowish-green crystals which are isolated or arranged in tufts, sheaves, and radiating rosettes; among the crystals one frequently finds brownish scales and granules.

The formation of similar crystals occurs when the urine contains glycuronic acid; the needles are, however, shorter and thicker [melting point 150° C.].

[Maltose and lactose may also form with phenyl-hydrazin acetate corresponding osazons. But the crystals of these compounds present a different appearance, and their melting point is lower than that of the glucose salt. The phenyl-glucosazon crystals melt at a temperature of from 204° to 205° C., for references see *Halliburton.*]

II.—ORGANISED SEDIMENTS.

Epithelium.

(Plates X., XII., XIII., XIV., and XX.)

Isolated epithelial cells, chiefly of the squamous type, are met with in most specimens of healthy urine, but when present in large numbers they may indicate the existence of some morbid process.

It is frequently possible to determine the place of origin of the cells by their form. In certain pathological, particularly inflammatory, conditions, the proliferation and desquamation taking place normally in the transitional and stratified epithelia proceed more rapidly and less regularly, so that cells derived from the middle and deeper layers of these inflamed epithelial membranes may be met with in the sediment. In such conditions the cells vary in size and form according to the particular layer from which they are derived, and to the parts of the urinary passages which are chiefly affected.

> [They are also modified in several ways under the influence of the various forms of irritation which, according to their nature and intensity, give rise to more or less rapid proliferation.]

The epithelia lining the various parts of the urinary tract present certain characteristic features, yet isolated cells coming from different regions occasionally resemble each other so closely that it may be impossible to determine with certainty their place of origin, a difficulty which is considerably increased by the swelling and alteration of shape which occur previously or subsequently to their passage into the urine.

It is of some practical importance to be able to decide whether epithelial cells are derived from the kidneys or from the urinary passages. As a rule, the following general features will be found sufficient for this differentiation:—

(α) **Renal Epithelium.**—The cells are cubical or round, somewhat larger than leucocytes, and possess large well-defined nuclei; at times, particularly in nephritis, they show evidence of fatty degeneration.

(β) **Epithelium from the Urinary Passages.**—The cells vary considerably in form; they are either squamous, rounded, elongated, or tailed, the latter being, as a rule, derived from the renal pelvis [or from the bladder.] Squamous epithelium is met with very frequently in the urine of females; the differentiation of vesical and vaginal epithelium is neither easy nor certain.

[A tabulated statement of the various forms of epithelia lining the renal tubes, urinary passages, and annexes may prove useful. Before attaching any importance to the presence of cells presenting certain characters, it is necessary to satisfy one's self that the origin of these cells can be established in a satisfactory manner by those characters. The following table shows the necessity of great caution in this respect:—

A. Kidney.—*Parts of the Urinary Tubules from which, probably, cells do not pass into the urine* (i.e., *in a state which would allow of their being recognised*).

Part of the Urinary Tubule.	Kind of Epithelial Cells.*
Capsule of Bowman.	Flat and cubical cells.
Proximal convoluted tubule and spiral tubule.	Striated or "rod" cells (granular, generally large and polyhedral, with a large round nucleus).
Loop of Henle and its proximal limb.	Flat or cubical cells.
Distal limb of the loop.	Flattened "rod" cells, which may contain pigment.
Irregular tubule.	Large and small "rod" cells.
Distal convoluted tubule.	Large "rod" cells.

B. Kidney.—*Parts of the Urinary Tubules from which cells may, more or less readily, pass into the urine.*

Curved (junctional) collecting tubule.	Very low cubical cells.
Straight collecting tubule.	Cubical cells, becoming columnar near the apex of the pyramids of Malpighi.
Excretory or papillary duct.	Columnar cells.

C. Urinary Passages.

Pelvis of the kidney and ureter.	Transitional epithelium (thick, flat, pear-shaped or tailed, oval and spherical cells, with comparatively large nuclei.
Bladder.	Transitional epithelium, with a greater number of flat cells than in the ureter and pelvis.
Mucous glands of pelvis, ureter, and bladder.	Columnar and cuboidal cells.

D. Genito-Urinary Passages in the Male.

Urethra (prostatic portion).	Transitional epithelium.
,, (spongy portion).	Long columnar cells.
,, (fossa navicularis, meatus, surface of glans, and prepuce)	Stratified squamous epithelium. Superficial cells, squamous and resembling closely vaginal epithelium.
,, Glands of Tyson.	Sebaceous cells.
,, Cowper's glands, glands of Littré.	Cubical, spheroidal, and columnar cells.
,, Prostatic glands.	Columnar cells.
,, Ejaculatory ducts. ,, Seminal vesicles. ,, Vas deferens.	Columnar cells.
,, Canal of the epididymis.	Very long columnar cells, most of them with long cilia.
,, Vasa efferentia.	Columnar ciliated cells.
,, Rete vasculosum and tubuli recti.	Cubical and flat cells.
,, Seminal tubules.	Small amœboid cells (seminal cells). Spermatozoa, mature and immature.

* The general characters only are given here, slight differences could not be made out in shed cells, altered by disease or prolonged stay in the urine.

E. Genital Passages and Vestibule in the Female.

Mucous membrane of labia and vestibule.	Stratified squamous epithelium.
Sebaceous glands.	Sebaceous cells.
Mucous crypts and glands of Bartholin.	Columnar, cubical, spheroidal cells.
Vagina and vaginal portion of cervix.	Stratified squamous epithelium.
Uterus and Fallopian tubes.	Columnar ciliated cells.]

Vaginal Epithelium.

(Plate XII., Fig. 6.)

The large squamous cells of the vagina are frequently shed in the form of shreds composed of several cells still connected together. The cells have an irregular polygonal form, with more or less distinct outlines; the edges are frequently turned over and are thinner than those of vesical cells. The protoplasm is finely granular [usually very transparent], and contains, as a rule, a single, nearly central, oval or round nucleus with a distinct nucleolus. [This nucleus, as a rule, is absolutely and relatively smaller than the nucleus of flat cells from the bladder.] These cells, which resemble epidermic scales, are constantly present in small quantity in female urine. In vaginitis they are present in great abundance, and to the unaided eye they may then appear as small white flocculi.

[Vaginal cells, seen on edge, look like thin spindle cells with a central bulging corresponding to the nucleus. Like other cells they are often covered with bacteria, or amorphous deposits. It is not often possible to say whether the squamous cells, which are usually described as vaginal, come from the vagina, or from the mucous membrane of the vulva. It is, therefore, not very safe to assume that a patient is suffering from vaginitis simply because a large number of epithelial scales are found in the urine. Even when they are associated with pus, their presence may be due to vulvitis. Vaginal and vulvar epithelial scales may be found abundantly in the absence of any inflammation of the mucous membrane, for instance, after exercise causing friction, and as a result of accumulation, of secretions, the consequence of uncleanliness. When such cells are present in abundance it is probable that the urine is from a female patient, but it would be unsafe to consider their presence as absolutely *diagnostic of sex*, since similar cells are met with, but usually in small quantity, in the urine of males; even the presence of spermatozoa does not prove that a urine is not from a female patient, for spermatozoa may remain in the vagina for several days, almost unaltered.]

Vesical Epithelium.

(Plate XIII.)

Cells from the vesical mucous membrane are generally isolated; they vary considerably in form and size, and may reach considerable dimensions (30μ to 60μ in diameter). The protoplasm has a cloudy and granular appearance and contains one, two, or more large, rounded, vesicular-looking nuclei, in which small bright nucleoli

may be seen. The cells from the superficial layers of the mucous membrane are polygonal or rounded in form; those from the middle layers are pear- or irregularly spindle-shaped, and provided with one or several processes (tailed cells)*; the cells from the deepest layers are smaller and of round or oval form (Plate XIII., Figs.

A.

B.

C.

Fig. 10.—Vesical Cells and Leucocytes (× 200). From the sediment in a case of chronic cystitis (during a period of exacerbation. See text).

A.—Appearance of the cells at the time the urine was voided, the reaction being then neutral. A small group of swollen vesical cells, large and small; lymphocytes and leucocytes, some of them with hyaline processes resembling pseudopodia; three of these cells were drawn a second time after an interval of fifteen minutes: they had retained their relative position, and there had been but a slight change in the size and shape of the pseudopodia-like processes.

B.—Gelatinous sediment (so-called "ropy pus") formed at the bottom of the vessel after the urine had become strongly alkaline. The cells were imbedded in a thick, ropy, transparent material: they had become swollen, soft, and adhesive. In this material, spread upon a glass slide for microscopical examination, many groups of softened pus-corpuscles were drawn into long spindle-shaped masses.

C.—Four vesical cells in various states of degeneration; one, with two nuclei, is very slightly altered; another is in a state of fatty degeneration; two others are distended with a clear substance and very near rupturing; they closely resemble chalice-cells.

2 and 3). Vesical cells are sometimes found united by their processes. In cystitis these cells are present in abundance, particularly in the acute forms of this disease (Plate XIII., Fig. 1).

* The resemblance between the epithelium of the bladder and that of the pelvis of the kidney must be kept in mind. The reactions of the urine may help one to surmise the probable origin of these cells, for the urine is generally acid when the pelvis alone is affected, whilst it is frequently alkaline in cases of cystitis.

[In cystitis, and more especially in chronic cystitis, when the urine has become alkaline, the majority of the bladder cells found in the urine may be so swollen as to be unrecognisable. In such cases they are often held in a ropy mucoid substance, where they are associated with pus-corpuscles (also swollen, softened, and deformed), crystals of triple phosphates, and sometimes urate of ammonium and phosphate of calcium. The cells which are not so profoundly altered are either in a state of dropsical infiltration, or mucous degeneration, as is shown by their becoming more and more spherical, until they assume the form of large, clear vesicles with a nucleus, surrounded by more or less granular protoplasma, pushed to one side. These changes are essentially due to physical and chemical alterations taking place in dead cells, for they are often observed in the urine long after it has been voided. This is specially noticeable during the alkaline fermentation. Ultimately the distended and softened cells break down, and take part in the formation of the viscid material usually described as mucus, or, when mixed with pus, *ropy pus;* other cells than vesical cells may undergo the same changes—*e.g.*, vaginal cells, pus-corpuscles, &c. See Fig. 10.]

Urethral Epithelium.

(Plate XIII.)

In *males* one meets with cylindrical cells (see Plate XIII., Fig. 4) (20μ to 28μ in diameter), and small spindle-shaped, pyriform, oval, and round cells from the deeper layers of the epithelial lining.

In *females* the cells are, as a rule, larger, those of the superficial layers being squamous like vaginal squames, but smaller, whilst those of the deeper layers are oval or rounded.

Urethral epithelial cells are met with in urethral catarrh, and especially in acute and chronic gonorrhœa ; they are usually altered in appearance.

Glandular Epithelium (*Prostate, Cowper's, Littré's Glands*).

(Plate X.)

The cells have in all cases a cubical or cylindrical form, frequently tapering at one end, and possess large nuclei ; Fig. 5, Plate X., was taken from a case of *prostatitis* with hæmaturia occurring in a man aged fifty-six years. The cells are arranged in irregular groups (palisade like) ; a few are isolated ; their free ends are stained to various depths by blood pigment. Blood stained vesical cells are also present.

Epithelium of the Renal Pelvis (Plate XIV., Fig. 1) and of the Ureter (Plate XIII., Fig. 6).

The cells are of various forms and often difficult to distinguish from other epithelia. They often possess long uni- or bipolar processes ; they may be confused with cells from the middle layer of the vesical epithelium, and especially with those from the neck of the bladder and prostatic urethra.

Besides the so-called tailed cells, which are abundant in the renal pelvis, small round or oval cells, sometimes grouped in a tesselated fashion, are also present.

Renal Epithelium.

(Plates X., XIII., and XX.)

Renal cells may occur free or in groups of various sizes. Many of the cells may remain connected, being shed together; these groups of cells retain the shape of the tubule from which they come and of which they form casts (epithelial casts in acute nephritis—Plate XX., Fig. 1).

Renal epithelial cells may be polygonal, swollen and rounded, or oval; they vary in diameter from 12μ to 25μ or more (Plate XIII., Fig. 5); they are sometimes small and pale; at others, somewhat larger and granular, and often of a yellowish or brownish colour (*e.g.*, in hæmorrhagic nephritis); the single nucleus, which at times is scarcely visible, is large, bright, round or oval in form.

Sometimes it is difficult to distinguish renal cells from swollen white blood-corpuscles; this is possible only when the renal cells preserve their sharp outline and characteristic nucleus.

Not infrequently the renal cells are in a condition of albuminous or fatty degeneration. The protoplasm often contains pigment granules (in hæmorrhages) and large and small fat granules which may be set free by the disintegration of the cell; these fatty or granule-cells resemble colostrum corpuscles; they occur, specially in cases of large white kidney, either free or imbedded in casts. Free nuclei, which may be mistaken for leucocytes, are also met with in the urine in such conditions.

Renal epithelium is frequently present in cases of acute and chronic renal disease (see p. 71); it is often fatty in connection with the latter.

The diagnosis of isolated epithelial cells in the urine is rendered difficult by the alterations of form produced by swelling, shrinking, and other degenerative changes which the cells undergo after they have remained some time in the urine. Certain concomitant conditions are often of assistance in this repect—*e.g.*, the concurrence of albuminuria and epithelial casts, of gonorrhœal threads, the existence of leucorrhœa, and so on.

In bile-stained urines the cells are often bile stained (see Plate X., Fig. 6).

Albumen Granules (Epithelial Débris).

(Plates XXVII. and XXXII.)

They are the product of degeneration and disintegration of cellular elements, and are met with particularly in chronic diseases of the kidney (*e.g.*, contracted kidney); they may form a deposit which, to the unaided eye, resembles very closely the white phosphatic sediment.

Microscopically, the granules may be seen forming distinct masses within degenerated cells; they may be free, evenly distributed or in irregular clumps (Plate XXVII., Fig. 2); lastly, they may be contained within casts (the genuine granular casts) (Plate XXXII., Fig. 2).

Sometimes, particularly on the addition of certain substances to the urine (acetic acid, alcohol), the disintegrated protoplasm appears in the form of small granules grouped round free and indistinct nuclei.

These albuminous granules are frequently described as masses of débris. Small and large fat drops are generally found mixed with them; the fat globules may be recognised by their bright appearance and by their reaction with Sudan III., osmic acid, &c. Albuminous granules may be confused with *bacteria*, or with *amorphous urates*, especially sodium urate. Bacteria may be readily differentiated, owing to the ease with which they can be stained with basic aniline dyes and by their resistance to acids and alkalies. Urates are characterised by their solubility on heating and reprecipitation on cooling, by their solubility in hydrochloric acid, followed by the deposition of uric acid crystals (which usually follows, within a quarter of an hour, after the addition of the acid).

Fibrin.

(Plates XV. and XVII.)

Fibrin is met with in the urine in hæmaturia, chyluria, in deep and pseudo-membranous inflammations of the urinary passages (tuberculosis, diphtheria, cantharides poisoning), in villous tumours of the bladder, and, lastly — but rarely — in (non-hæmorrhagic forms of) nephritis. Masses of fibrin may be present in the urine when it is voided, but, as a rule, they do not appear until a few minutes after. The urine then presents the appearance of a hæmorrhagic fluid in which a veil-like cloudiness, large flocculi, red or yellowish-red coagula may be seen. When one attempts to remove these clots from the urine they shrink into dense, lumpy, tenacious, mucus-like masses (Plate XV., Fig. 2), and often resemble the ropy sediment usually associated with excessive secretion of mucus (*e.g.*, in vesical catarrh).

At times, when a very considerable quantity of fibrinogen is present, the whole urine may clot, a tremulous jelly-like mass being produced, which can scarcely be poured from the vessel.

By boiling the coagula (after washing them in water), for some time, in a ½ per cent. solution of hydrochloric acid, or a 1 to 2 per cent. caustic soda solution, the fibrin in great part dissolves, and the solution gives distinct albumen reactions (*e.g.*, with acetic acid and potassium ferrocyanide).

Microscopically, the fibrin coagula may be recognised by their fine fibrillar structure and their positive reaction to Weigert's fibrin stain. Among the fibrillæ one frequently sees a few red and white blood-corpuscles, fat globules, &c.

The fibrin threads frequently form a delicate reticulum (Plate XVII., Fig. 2).

Spermatozoa.

(Plates XIV. and XVIII.)

Spermatozoa are found in the urine of men for some time after the occurrence of coitus and after masturbation. They appear in large numbers in the urine directly after the emission of semen, especially in spermatorrhœa; they are occasionally found after epileptic or other spasmodic seizures, and also in severe illnesses, especially typhoid fever.

At first they may exhibit some motility, undulating motion of the tail, but this is soon lost, especially when the urine is alkaline. When motionless and dead they lie either extended or with their tails looped up. They retain their characteristic form for a great length of time, weeks or even months.

The occurrence of numerous very much smaller bodies [seminal cells] is pathological, [and indicates considerable loss of semen (*Clemens*, see *Neubauer* and *Vogel*)]; occasionally immature spermatozoa with caps [or rather with a mass of protoplasm attached to the middle piece or anterior end of the tail] are met with (Plate XIV., Fig. 3, just above the centre of the figure). Along with the spermatozoa one occasionally observes, in cases of spermatorrhœa, broad, hyaline cylindrical structures (so-called spermatic casts); these will be referred to again in the section on *Urinary casts* (p. 73).

The spermatozoa are easily recognised by their characteristic form. They are elongated, pin-like structures presenting a head, neck (or middle piece) and tail. The head is laterally compressed and pear-shaped, being narrow anteriorly, or it may be more rounded in form; it has a slightly shining appearance; joined on to it is the sharply-defined awl-shaped middle piece [*Schweigger-Seidel*], which becomes thinner from before backwards, and is continued by the thin flagellum-like tail. The head is 3 to 4 μ long and 2 to 3 μ broad, the neck 6 μ long and about 1 μ broad, the tail 40 to 50 μ long.

The addition of dyes to the urine shows that the head of the spermatozoon is not homogeneous. By using strong solutions of dyes (eosin, methylene blue) a sharply-defined round or oval vesicular body may be demonstrated in the posterior part of the head, the anterior part of the head, the neck, and tail being only faintly stained (Plate XVIII., Fig. 3); or, if weaker solutions are used, the tail does not stain at all.

[By careful search with the aid of centrifugalisation, it is possible to find a few spermatozoa in many specimens of urine, but the discovery of a few stray spermatozoa has no clinical significance. On the other hand, when these structures are usually present in the urine, and many of them are evident in the course of an ordinary microscopical examination, some importance may be attached to their presence.

From the series of 600 microscopical examinations, which have already been used in connection with oxalate of lime and phosphates, the editor has obtained the following data:—

Spermatozoa were found in 20 specimens—*i.e.*, in 3·3 per cent. of the cases; abundant in 6 cases; in moderate numbers in 6 cases; and scanty in 8 cases.

The urine was from male patients in 19 cases, and from a female patient in 1 case.

The specific gravity of the urine was—

1010 to 1014 in 3 cases.	1020 to 1024 in 8 cases.
1015 to 1019 in 3 ,,	1025 to 1030 in 6 ,,

The specific gravity had, therefore, a tendency to be above the normal. In 5 out of the 6 cases in which the specific gravity was below 1020, there was abundant evidence of the existence of chronic nephritis, and in 3 of the cases in which the specific gravity was above 1020 there was also evidence of renal inflammation (acute or subacute in 2 of them). In 8 of the other cases there was irritation of the bladder or urinary passages (very acute in one instance).

Albumen was clearly present in 18 out of the 20 cases; it was abundant or moderately abundant in 4 cases; and scanty, but quite evident, in 14 cases.

A small amount of glucose was found in 6 cases.

Oxalate of lime was very abundant in 2 cases; moderately abundant in 2 cases; scanty in 3 cases; and absent in 12 cases. There seemed, therefore, to be no distinct relation between the presence of oxalate of lime and that of spermatozoa.

Uric acid was found abundantly in 4 cases, and was absent from all the other specimens (in one instance it was associated with oxalate of lime).

Phosphate of calcium was present in 1 case; triple and amorphous phosphates in 1 case.

With regard to the appearance of the sediment there was nothing characteristic about it. In 3 cases semen was abundant enough to form in the urine flakes visible to the naked eye and resembling masses of mucus or muco-pus. In 2 cases spermatozoa were abundant enough to be found, microscopically, in almost every drop of the fluid, and there was nothing more than a faint turbidity to indicate their presence. In all other cases the presence of epithelial cells, pus, mucus, blood (1 case), various crystals, gave to the sediment the appearance usually associated with those products.

The general impression left by these observations is that spermatorrhœa seldom occurs by itself, but is a tolerably frequent complication of lesions of the genito-urinary tracts.

A very large number of spermatozoa may be present in the first urine passed after ejaculation. In two cases the urine was found to contain elongated masses resembling urethral threads (see p. 64).

In Fig. 11 part of such a mass is represented; it measured about $\frac{1}{2}$ inch in length, and was imperfectly cylindrical in shape. It had apparently taken the shape of the urethra (urethral cast). It was almost opaque, yellowish-white, soft and flocculent in the centre, denser and more membranous looking at the periphery. It was soft and easily torn. It had evidently lain in the urethra a few hours before being expelled. On microscopical examination it was found composed of a coarse network, holding together numerous spermatozoa, mature and immature, spermatic cells, and granular débris.

In Fig. 12, spermatozoa found in a female urine are represented. They are imbedded in a mucous shred. Vaginal cells, some coated with bacteria, small epithelial cells, oxalate of lime crystals, and bacteria are also shown in the figure.

Fig. 11.—Portion of a Urethral Cast composed of Coagulated Semen (× 210) (see Text).

Fig. 12.—Vaginal Cells, lower group covered with bacteria, Leucocytes, Mucous Shred containing Spermatozoa, Oxalate of Lime, Bacteria (× 210). From the urine of a female patient.

Mucus (Mucin).

The quantity of mucus in the urine is increased in catarrh of the urinary passages and in febrile diseases generally; it may occur under the following forms.*

I.—Nubecula (Cloudy Deposit, Mucus).

In healthy urine small clouds of mucus are always present, being derived from the mucous glands of the urinary passages; in females the quantity of mucus is generally much greater than in males, owing to the admixture of the vaginal, and more specially vulvar, secretion with the urine. After the urine has stood for some time the mucin, together with the enclosed cellular elements (leucocytes, epithelium), subsides, and forms a cloudy sediment on the bottom of the vessel (see p. 2). When a large quantity of mucin is present in the urine, especially in cystitis, it forms a viscid gelatinous sediment.

[A considerable portion of this so-called mucus is composed of albuminous products resulting from the disintegration of epithelial cells, and leucocytes or pus-corpuscles. This is well shown by the changes occurring in purulent urines which are acid when voided. In such urines the pus-corpuscles are at first quite distinct and not held together by any viscid substance. If alkaline fermentation is allowed to take place, the cells swell, become transparent and

* The recently reiterated view that the mucus deposit in urine is more of the nature of nucleo-albumen than genuine mucin requires still further elucidation.

adhesive, and ultimately many of them are replaced by a thick viscid substance. The ropy pus of chronic cystitis is probably to some extent produced in the same way; similar changes are observed in urine containing blood. The jelly-like substance which is found in all these cases generally contains a large proportion of alkali-albumen sometimes mixed with some altered mucin (see Fig. 10).]

II.—Cylindroids.

(Plates XIV., XXVIII., and XXXII.)

These are long, pale, delicate ribbon-like bodies consisting of mucus, showing fine longitudinal striation and frequently frayed out at the ends; they may (in part of their length) resemble hyaline casts (Plate XIV., Fig. 4; Plate XXXII., Fig. 1), but unlike the genuine casts they are not soluble in acetic acid.

Isolated cylindroids are found in the majority of normal and pathological urines. In inflammations of the mucous membrane of the urinary passages, especially of the bladder, they occur in large numbers. Occasionally they may be found along with genuine casts in nephritis. [Tube casts may even at times be covered with a mucous coating which gives them the appearance of cylindroids (Fig. 13).] They may also be found in bile-stained urines, in concentrated urines rich in urates, and in passive renal congestion, &c.

Fig. 13.—Part of an Epithelial Cast imbedded in Mucus (Cylindroid) Vesical Cells; small crystals of Oxalate of Lime (× 200).

Those cylindroids which, by some authors, have been termed urethral threads, are of special importance (p. 64).

Cylindroids, like true casts, may be covered with deposits of amorphous granules (urates, bacteria, pigment, crystals, cells, &c.—Plate XXVIII., Fig. 2). In such cases they may be mistaken for hyaline or granular casts.

The following features serve to differentiate them from hyaline casts :—

1. Cylindroids are of great length, often extending over several microscopic fields.

[In some cases true hyaline casts are also of considerable length, but, on account of their brittleness, these long casts are seldom observed.]

2. They have a very variable diameter.

3. They frequently exhibit sharp twists and bends, similar to those which may be produced by twisting a ribbon. [Tube casts cannot usually form sharp angular bends without breaking.]

4. They almost always exhibit a delicate, longitudinal striation.

5. On addition of acetic acid they give the mucin reaction.

[It is necessary to keep in mind that the term cylindroid has been applied by various writers to different products. Thus, according to *v. Jaksch*, cylindroids are more closely allied to hyaline casts than to mucous threads; in fact, from the descriptions given by that author it would appear that cylindroids are imperfectly formed hyaline casts, for, according to him, they have the same chemical reactions. They would differ from them only on account of the irregularity of their shape, and of the length they may acquire. It is easy to convince oneself that hyaline casts are very liable to irregular formation; the same cast may have in part of its length the appearance of a hyaline and even of a colloid cast, and

Fig. 14.—Tube Cast partly Hyaline partly Colloid (shaded part) (× 200); one end of it resembles a cylindroid.

present in other parts the characters which v. Jaksch gives to cylindroids. The editor has observed many instances of these transitional forms, one of which is represented in Fig. 14. It is, therefore, better to reserve the name cylindroids (*i.e.*, cast-like bodies, or false casts) for the mucin threads, which may at times be mistaken for true casts or cylinders, but are not moulded (or partly moulded) in renal or other glandular tubes.]

III.—Urethral Threads.

(Plates XV., XVII., and XVIII.)

These are formed by the mucous secretion of the urethra, of the glands of Littré, of Cowper, and of the prostate. They are found in the urine in some cases of sexual neurasthenia, with or without spermatorrhœa; they are more common in chronic urethritis following gonorrhœa, especially in the morning urine, in which large and small mucous threads may be seen floating about (gonorrhœal urethral threads). They vary in length from some millimetres to several centimetres; as a rule, they are

extremely thin, but sometimes appear as transparent or opaque, yellowish-white, muco-gelatinous bodies of the thickness of a needle.

They are composed of mucin in which various cells—pus-corpuscles, coarsely granular cells, epithelial cells—from the urinary passages are generally imbedded.

Gonorrhœal Threads.—In cases of gonorrhœa, the threads frequently contain gonococci, but these may be absent in mild cases. At times, particularly in the early stages of the disease, the gonorrhœal threads contain also red blood-corpuscles, blood pigment, uric acid crystals, and spermatozoa. Fresh urethral threads may be stained by allowing first a watery solution of methylene blue to flow under the coverglass, and then, in about half a minute, washing away the superfluous stain with water.

In Plate XV., Fig. 3; Plate XVII., Fig. 3; and Plate XVIII., Fig. 4, fresh, gonorrhœal threads, observed in the urine of a man suffering from gonorrhœal urethritis, are represented, some unstained, others stained with methylene blue.

Mucin Reactions.—The production of a coarsely granular turbidity, on the addition of acetic acid, serves as a micro-chemical test to distinguish the above structures (cylindroids and urethral threads) from other similar structures. Mucicarmine (*P. Mayer*), which stains all mucous substances a characteristic red colour, affords a still more valuable means for their recognition.

Erythrocytes (Red Blood-corpuscles).

(Plates VII., XV., XVI., XXIII., XXV., XXVI., XXX., XXXII., and XXXVI.)

Unaltered red blood-corpuscles are readily recognised by their round biconcave form and faint yellow colour. They present different appearances according as they occur in acid or alkaline urine; in the former they persist a long time, but are rapidly destroyed on the occurrence of alkaline fermentation. Their appearance is also influenced by the degree of concentration of the urine and by the length of time they have been in the urine.

In concentrated urine small and crenated forms are most often met with, whilst in dilute urine they have a pale washed-out appearance or their colourless stromata appear as faint, swollen, biconcave discs [or as spheres], the so-called blood-shadows [phantom corpuscles of *Traube*].

After standing for some time in acid urine the corpuscles present numerous variations in size, form, and colour (Plate XV., Fig. 1).

Red blood-corpuscles may be aggregated together in cast-like masses, or they may enter in the composition of other urinary casts (Blood casts, see p. 71; and Plate XVI., Fig. 1, &c.). Sometimes thread-like, vermiform clots are formed within the urinary passages; this occurs specially in cases of vesical haemorrhage.

Occasionally red corpuscles seem to be undergoing division or to be endowed with amoeboid movement, this may sometimes be observed even twenty-four hours after the urine has been voided; processes are thrown out and withdrawn by the corpuscles, and finally knob-like protuberances form, which are gradually constricted off from the cell.

[Nature of **spurious amœboid motion** of cells in urinary sediments.

There can be no doubt that, in most cases, the alterations of shape giving rise to amœboid-looking motions, are due to osmotic phenomena and probably also to unequal shrinking of the various elements of the corpuscles. That the movements observed are not signs of vitality is indicated by the following facts :—

They are equally well marked in warm and in cold urine.

They may be observed, in acid, neutral and slightly alkaline urines (of low specific gravity), and in fact cease to be manifest only when, through excess of alkalinity due to fermentation, the cells undergo complete disintegration.

The extrusion of these "pseudopodia" is seldom associated with any displacement of the cell, and when such a displacement takes place it is generally slight and probably due to the shifting of the centre of gravity due to alteration of shape.

The pseudopodia-like processes are composed of a hyaline, soft substance, which is capable of swelling rapidly (see Fig. 10, p. 56)

In freshly voided urines, leucocytes may occasionally exhibit *true amœboid motion* for a short time. Spermatozoa under the same conditions are capable of sluggish motion, but soon become motionless.]

In the male subject, red blood-corpuscles always indicate some morbid change—*e.g.*, hæmorrhages from the urinary passages or the kidneys; in females, they not unfrequently owe their origin to menstruation.

Diagnosis of the place of origin of the red blood-corpuscles cannot generally be made independently of the consideration of other symptoms.

Leucocytes (White Blood-corpuscles, Lymphocytes, Pus-corpuscles).

(Plates VIII., XIV., XV., XVI., XXII., XXIII., &c.).

The characters of these cells vary with the reaction and other properties of the urine. They are larger than red blood-corpuscles; rounded, granular, generally colourless, and contain one or more nuclei. In acid urine they generally appear very granular. The nuclei can be rendered visible by treatment with acetic acid, which dissolves the granules (Plate XIV., Fig. 5). In alkaline or ammoniacal urine the leucocytes become swollen, glassy and transparent; and their nuclei are, as a rule, visible (Plate XXII., Fig. 4); but after a long stay the cells undergo disintegration, their outline gradually disappears, and, finally, free nuclei alone remain. The leucocytes are frequently in a condition of fatty degeneration; this is not unusual in chronic cystitis. In fresh urine containing blood, and particularly urine from cases of cystitis, the leucocytes frequently exhibit amœboid movement (Plate VIII., Fig. 4), which may last for many hours or even days (see annotation above).

In hæmaturia the leucocytes (and nuclei of epithelial cells) are often stained with blood pigment (Plate XXIII., Fig. 1).

When the leucocytes are swollen (as occurs especially in very dilute urines) it may be difficult to distinguish them from epithelial cells, and the addition of a little iodo-potassium-iodide solution sometimes renders diagnosis easier; the leucocytes staining a

greyish-brown [glycogen reaction (?)], whilst the epithelial cells assume a light yellow colour.

A few isolated leucocytes may be found in almost every urine, either normal or pathological; they occur abundantly in inflammatory lesions of the urinary passages and kidneys, and they are also abundant in leucorrhœa. Pus-corpuscles are especially numerous in suppurative inflammations of the urinary organs and when an abscess of some neighbouring organ ruptures into the urinary passages (**pyuria**). In such cases they form a greyish-greenish-white flocculent deposit, which becomes viscid and ropy when the urine undergoes alkaline fermentation. The leucocytes instead of being free may be aggregated together in cast-like masses, or (in nephritis) they may be deposited on true casts (see *Leucocyte casts*, p. 71).

The place of origin of the leucocytes can only be inferred from their association with the other elements of the sediment, when the source of these is evident [the observer must also be guided by the other symptoms.] *Senator* holds that in nephritis uninuclear leucocytes preponderate, whilst in cystitis the multinuclear leucocytes are the more numerous in the urine.

Casts (Urinary Casts—[Tube Casts, Urinary Cylinders]).

These are casts of the urinary tubules, appearing in the sediment as straight or convoluted structures of various diameters and various lengths. The straight casts originate in the tubuli recti, the convoluted in the tubuli contorti.

> [It is probable that very few of the tube casts found in the urine are actually formed, as such, in the convoluted tubes; even casts which present a convoluted appearance are usually formed in the straight tubes. When casts, formed in the narrower collecting tubules (very often out of the products coming from the secreting tubes), are forced into larger tubes, they may rapidly escape and remain straight, but, on meeting an obstacle, they may bend upon themselves or be forced to assume a wavy or convoluted shape.]

Renal casts are almost invariably associated with albuminuria, and they indicate, with few exceptions, the existence of some renal lesion. After severe exertion, however, hyaline tube casts have been found in the urine of persons free from disease of the kidneys.

The diameter of each cast shows a characteristic uniformity except at the two extremities—one of which is either rounded or pointed, whilst the other is frequently broken across; they are generally shorter than cylindroids. Sometimes only small fragments of casts are found, and occasionally they exhibit bifurcations corresponding to the branching of the renal tubules.

In acid urine casts remain intact for a considerable time, but in alkaline urines they rapidly disappear (and so differ from the cylindroids). Urinary casts are divided according to their appearance and characters into several varieties.

> [Urinary casts are in the great majority of cases derived from the renal tubes, but occasionally one meets in the urine similar structures derived from other glands connected with the urinary tracts.

Besides these microscopic casts one finds occasionally in the urine casts of the larger urinary passages, more specially of the ureters and urethra (see p. 62).

Several of these morbid products have come under the editor's notice. The most remarkable was a **cast of the ureter** in a patient suffering from sarcoma of the kidney. This cast was cylindrical, pointed at both extremities, and measured over 5 inches (13 centimetres) in length. It resembled so closely an *Ascaris lumbricoides* that it was supposed, by the patient, to be one of these parasites, and its presence in the urine seemed difficult to account for. It was composed of sarcomatous masses mixed with decolourised blood-clots. Another cast of the ureter presented similar appearances, but was less regular in shape, and shorter; it was found to be composed entirely of partly decolourised blood-clots, the case was also one of tumour of the kidney.

The passage of such casts down the ureter is associated with symptoms of renal colic, and partial or complete cessation of hæmaturia; this last symptom, however, generally re-appears as soon as the pains cease—*i.e.*, as soon as the cast has reached the bladder. After a variable interval of time, stoppage of urine occurs, due to obstruction of the urethra by the cast; this obstruction remains more or less complete during the passage of the cast down the urethra.

Clots and portions of tumours coming from the bladder may become elongated during their passage through the urethra, but well-defined casts of the urethra are not likely to occur.]

Hyaline Casts.

(Plates XV., XVII., XXII., XXIV., &c.)

These casts are found in the urine in cases of renal ischæmia and hyperæmia; in diffuse nephritis, and specially in interstitial nephritis and amyloid degeneration [lardaceous infiltration] of the kidneys; in the last two conditions the hyaline casts are frequently coated, more or less completely, with finely granular urates or albuminous débris. These deposits give to the casts a finely granular appearance. There is no definite ratio between the number of these casts and the severity of the morbid process.

Hyaline casts are straight or convoluted, transparent, homogeneous, delicate bodies (they are particularly delicate in passive renal congestion; Plate XXIV., Fig. 2), their length, breadth, and form vary; they may be stained yellow by iodine solution, or violet by a very dilute watery solution of gentian-violet; they may also be rendered evident by oblique illumination [or, better still, by reducing considerably the aperture of the substage diaphragm]. In bile-stained urine they have a yellow or yellowish-green colour (Plate XV., Fig. 5; and Plate XXXV., Fig. 1); in hæmaturia or hæmorrhagic nephritis they are brownish-red or yellow (Plate XXX., Figs. 1 and 2).

Hyaline casts are not infrequently covered by cells (renal epithelium, red blood-corpuscles, leucocytes) and the products of their disintegration (see p. 72), as well as by non-organised constituents—*e.g.*, urates.

(For their differentiation from cylindroids, see p. 63. See also *Colloid casts*, and *Granulated casts*, p. 70.)

Waxy Casts [Colloid Casts].

(Plates XIV., XVII., XIX., and XXXI.)

These bodies are supposed to result from degeneration of the renal epithelium. They are frequently found associated with chronic renal diseases, such as the various forms of chronic nephritis—*e.g.*, the contracted kidney of chronic lead poisoning; they are present in the urine in cases of lardaceous infiltration (amyloid degeneration) of the kidney, but their presence is not characteristic of this condition. Their occurrence in the urine is always indicative of serious lesions.

Waxy [colloid] casts are highly refractive, homogeneous, sharply-defined bodies having a peculiar dull opaque lustre; they are generally straight, rarely convoluted (Plate XVII., Fig. 5), frequently coloured faint yellow (Plate XIV., Fig. 6), and sometimes exhibit lateral indentations. They are often remarkably broad, generally much broader than hyaline casts, and vary considerably in length. The casts are often longitudinally fissured (Plate XXXI.) and more or less completely broken across, the surfaces of section in such cases are often sharply defined and circular; unless great care is used in the treatment of the sediment, casts of large diameter are not found. Waxy [colloid] casts are but rarely the seat of granular deposits.

As a rule they do not give the amyloid reaction (Plate XIX., Fig. 6). To reckon the so-called *amyloid* [lardaceous] *casts* as a special subdivision appears to be incorrect, since hyaline and other casts may give the amyloid reactions—*i.e.*, red colouration, after treatment with methyl violet and mahogany-brown colouration, after treatment with iodine solution. The presence of such casts in the urine does not indicate the existence of amyloid [lardaceous] degeneration of the kidneys.

[A *spurious lardaceous* (amyloid) *reaction* is often obtained with colloid casts which are allowed to remain in the midst of a fluid stained with methyl-violet; when, however, these stained casts are well washed with water, their pinkish colour rapidly disappears, which would not be the case had the casts really contained lardacein. The editor has seen only one specimen containing casts giving a clear lardaceous reaction, in the course of several thousand examinations.

The term "waxy cast" is unfortunate, and has undoubtedly been a source of misunderstanding. It is easy to satisfy one's self that these cylinders are essentially composed of that ill-defined material known to pathologists under the name of colloid substance. They swell under the action of acetic acid; no precipitate of mucin is produced in them by that reagent. They have all the physical characters of colloid matter; they behave like that substance with staining reagents, more specially picro-carmine, methyl-violet, iodine, and osmic acid. As in the case of accumulations of colloid matter in other parts of the body, their composition is not uniform, and several strata may sometimes be demonstrated in the same cast. In such cases the most central parts may be typically colloid, whilst the peripheral layers may resemble more closely the hyaline matter composing *hyaline casts*, and may contain debris of degenerated cells. A narrow colloid cast may be wavy, bent upon itself, and imbedded in a larger hyaline cast. All these facts point to the conclusion that colloid casts are produced by a gradual chemical alteration of

albuminoid substances which have accumulated in the tubes of the kidney, and have not been expelled at once. These albuminoid products are chiefly due to degeneration of the renal cells; albuminous exudations from the blood-vessels probably gets mixed with these degenerative products. Examinations of kidneys, from which colloid tube casts are derived, have satisfied the editor that these casts can actually be shown to be produced in the way just described. The same view is supported by analyses of the contents of renal cysts. These cysts, according to their age, may contain (1) urinous or serous fluid; (2) viscid stringy fluid containing a mucin-like substance; (3) a soft colloid material containing no mucin, but a large amount of metalbumen and paralbumen. This substance, when not blood-stained, presents the same reactions as colloid casts. As might be expected, there are many intermediate forms between the colloid and the *hyaline tube* casts.]

Granular Casts.

(Plates XV., XVII., XXII., &c., XXVIII., XXXIII., XXXIV., &c.)

True granular casts are found in the urine in cases of acute nephritis, of chronic diffuse nephritis, and especially of interstitial nephritis. They are, as a rule, short, thick bodies composed of degenerated renal epithelium; they have a somewhat dark appearance, and their substance is generally granular throughout. The granules, consisting of albumen or (more rarely) fat, may be either coarse or fine, so that *coarsely* and *finely granular* casts may be distinguished. In icteric urine the granular casts are bile-stained (Plate XXIV., Figs. 3 and 4; Plate XXVIII., Fig. 2). A hyaline cast may be coated with granules of amorphous urinary salts; such a cast may be called "granulated," and differs from the true granular cast in that it is generally lighter, narrower, longer, not so densely granular, and frequently shows irregular transparent areas. Some spaces free from granules may be observed in grauular casts, these correspond to the branchings of the renal tubules. **Granulated hyaline casts** never show the peculiar indentations and markings corresponding to the outlines of the degenerated renal cells. The occasional occurrence of isolated epithelial cells in the casts at once decides the matter; also acetic acid (1 drop) may be of service in diagnosis, since it dissolves the urate granules.

[All kinds of casts are liable to become coated with urates, phosphates, bacteria, &c., the distinctions made here by the author have no important clinical significance.]

Epithelial Casts.

(Plates XVI., XX., and XXXII.)

The presence of these casts in the urine is an infallible indication of desquamation of the renal epithelium associated with disease of the renal parenchyma. They are met with especially in the early stages of acute diffuse nephritis and in chronic parenchymatous nephritis (large white kidney). **Epithelial tubes** (Plate XX., Fig. 1) consist of the epithelial lining of the renal tubules shed *en masse*. Epithelial casts may

also be composed of renal cells (generally in a condition of granular degeneration) imbedded in a hyaline or granular cast (Plate XVI., Fig. 2), the surface of which is covered more or less completely by the epithelial cells. Both forms, the epithelial tube and the epithelial cast, often occur together in the same urine. The cells have the characters of renal epithelium (see p. 58).

The epithelial tubes are found abundantly in the desquamative form of nephritis—*e.g.*, scarlatina nephritis; the epithelial casts are found in all forms of parenchymatous nephritis. Both forms may be covered with mineral and organic deposits. The epithelium may be in a condition of marked fatty degeneration, this giving rise to the presence of large and small fat drops in the casts (Plate XXXII., Fig. 2).

Fat Granule Casts (Fatty Casts).

(Plate XVI., Fig. 1; Plate XXIX., Fig. 2; Plate XXXII., Fig. 2; and Plate XXXIII., Fig. 2.)

Under this term are included casts which are closely beset with large or small fat globules; they are met with especially in fatty degeneration of the kidneys (see *Epithelial casts*).

Leucocyte Casts (Purulent Casts).

(Plate XVI., Fig. 1; Plate XXIII., Fig. 5; and Plate XXVI., Fig. 2, &c.)

These casts are not very common, being met with particularly in suppurative nephritis. They may consist of ordinary hyaline casts thickly coated with leucocytes, or of cylindrical masses of leucocytes held together by fibrin or mucus. The leucocytes may be either well formed or in a condition of degeneration.

Blood Casts.

(Plates XIV., XVI., XXX., and XXXII.)

This term is applied to casts which are densely coated with red blood-corpuscles (Plate XVI., Fig. 1; Plate XXX., Fig. 2; Plate XXXII., Fig. 1), and also to cylindrical blood clots formed within the renal tubules.

Both forms are a sure indication of the occurrence of renal hæmorrhage or of acute nephritis. Isolated red blood-corpuscles may also occur in hyaline and granular casts along with other formed constituents (Plate XIV., Fig. 2). In recent hæmorrhages the red corpuscles enclosed in the casts may be well preserved, but they are more usually swollen and decolourised, occasionally they may be deformed and present abnormal shapes in consequence of mutual compression.

In the later stages of renal hæmorrhage, flakes of pigment are more abundant than cellular elements, and both may be found in casts. When all the blood-corpuscles in a cast have disintegrated leaving only flakes of pigment, a pigment cast is produced.

Pigment Casts.

Pigment casts may be formed, not only by the breaking down of blood-corpuscles in blood casts, but also by the deposition of blood pigment, melanin, or indigo, in other

kinds of casts, or by the accumulation and more or less complete fusion of free pigment granules in the renal tubules. Pigment casts are met with in the later stages of renal hæmorrhage, in hæmoglobinuria (in such cases they are often termed hæmoglobin casts), and in melanotic tumours of the kidney (renal sarcoma).

Fibrin Casts.

Casts composed solely of coagulated fibrin are occasionally found in cases of renal hæmorrhage.

[They are usually ill-formed, granular, and become very transparent, almost invisible on the addition of dilute acetic acid; some fibrin probably enters in the composition of many other casts.]

Mixed Forms of Casts and Deposits on Casts.

Casts do not always appear in the simple forms described above. Thus, casts may be partly hyaline and partly granular owing to a deposition of urates, &c. Leucocytes and epithelial cells may occur along with red blood-corpuscles in the same cast. Fatty needles and calcium oxalate crystals may also be present.

[All the most important combinations have already been indicated in the previous sections. It is usual to give to a cast the name of the *most* important elements which enter in its composition; in the following figures examples will be found of hyaline tube casts containing, or covered with, various cells.]

Fig. 2, Plate XIV.—Red and white blood-corpuscles, also urates.
Fig. 2, Plate XVI.—Epithelium.
Fig. 2, Plate XXXV.—Bile-stained epithelium.
Fig. 1, Plate XXXV.—Fat granule cells, stained brownish-black by osmic acid.
Fig. 4, Plate XVII.—Leucocytes and fatty needles.

Ammonium Urate Casts.

(Plate XVI., Fig. 3.)

These bodies are met with in the urine of infants. They are the results of the uratic infarcts which occur fairly commonly in new-born children during the first two weeks of life; they have no pathognomonic significance. The casts are composed of coherent spheroids of ammonium urate; the spheroids are generally smooth or more rarely covered with numerous spines like small hedgehogs. Occasionally a cast may be seen with a thinner offshoot corresponding to a branch of the renal tubule. These casts give the usual reactions of urates.

Calcareous Casts.

They are composed of carbonate and phosphate of lime, and are occasionally found in the urine of adults suffering from nephrolithiasis. Like true casts they are moulds

of the renal tubules, and are therefore easily distinguished from renal casts which have become deformed by deposits of various salts on their surface, and also from pseudo casts produced by the same precipitates. The nature of these products must be determined by their chemical reactions.

Bacteria Casts.

May be formed in cases of suppurative nephritis of local or embolic origin, and in some other infective diseases. They are partly or entirely composed of bacteria, generally pyogenic cocci. True casts may be covered with microbes, but some casts are almost entirely composed of bacteria closely packed together. When bacteria are abundant in the lower urinary passages, they are frequently deposited on casts or on pseudo casts. They may be distinguished from various granules by their uniform size and shape, by their staining easily with basic aniline dyes, and by their resistance to the action of acids and alkalies. The diagnosis of bacteria casts can only be made in fresh urine, since in old urines bacteria may, like urates, form cylindrical masses resembling casts (Plate XV., Fig. 5).

Spermatic Casts.

They are formed in the seminal tubules [?], and are occasionally met with in cases of spermatorrhœa. They resemble hyaline casts in being pale and homogeneous, but are, as a rule, much longer and broader than these. The absence of albuminuria is an important point for their differential diagnosis.

[It is not easy to establish clearly the origin of tube casts coming from the *Vasa deferentia*, *Vesiculæ seminales*, or *prostatic glands*, unless they contain spermatozoa or amyloid bodies. The editor has observed such casts in a few instances. In Fig. 15, a small hyaline cast is represented: several spermatozoa are imbedded in its substance. The absence of albumen cannot be relied upon as a means of diagnosis between renal and seminal casts, for the presence of a moderate amount of spermatic fluid in the urine is associated with the presence of a slight, but distinct, amount of albumen. On the other hand, it is generally admitted that a few hyaline casts of renal origin may be present in urines containing so little albumen that it is usually overlooked.] .

Fig. 15.
Spermatic Cast (× 200).

Pseudo Casts.

(Plate XVI., Fig. 4; Plate XXXV., Fig. 2.)

There are some organic and inorganic formations which have a certain superficial resemblance to true urinary casts, and may be mistaken for these. They are termed "false or pseudo casts." Unlike true casts, they have no definite relation to diseases of the kidneys.

[Urates, phosphates, &c., deposited on mucous threads and rolled under the coverglass, may simulate true casts.

Uric acid, phosphates, oxalates, &c., may crystallise round threads or other filamentous structures and produce masses distantly simulating casts.

A very little practice and the use of the ordinary reagents will allow the beginner to avoid these sources of error.]

Tumour Cells and Débris.

(*Epithelioma and Villous Tumour of the Bladder.*)

(Plates IX., XVI., and XVII.)

Occasionally fragments of new growths may be found in the urine of patients suffering from tumours of the urinary organs and more specially of the bladder. This occurs chiefly when the tumour is undergoing ulceration and after catheterisation. Shreds of tumour may be recognised, even macroscopically, [as dense, often ragged, fibrous-looking] bright red or whitish masses; under the microscope their true nature is sometimes at once obvious (Plate XVI., Figs. 5 and 6); their structure may be in some cases rendered more evident by the use of histological stains. The most characteristic masses have the appearance of villi covered by a thick epithelial layer (Plate XVII., Fig. 6). The differential diagnosis of sarcoma, carcinoma, and papilloma of the bladder can be made with certainty only when comparatively large pieces of the tumour are available; it is then possible to harden them and prepare from them microscopical sections. Some of the elongated papillæ, or villi, of villous tumours (papillomata) are frequently torn off, even before these tumours have begun to ulcerate. These villi with their central vascular loop are so characteristic that a microscopical diagnosis presents no great difficulty. In epitheliomata, on the other hand, a diagnosis is possible only when the tumour is breaking down. The ulceration liberates masses of tissue, composed of groups, or nests, of irregular epithelial cells supported by a stroma of connective tissue. [Blood-corpuscles, clots, amorphous blood pigment, and] hæmatoidin crystals are frequently found associated with cellular débris. The presence of isolated polymorphous cells resembling those found in cancer is not enough to establish a proper diagnosis of tumour, except in very rare cases, for it is almost impossible to distinguish between the epithelial cells of the urinary passages and the cells of carcinomata or sarcomata. Urines containing fragments of tumours contain also, as a rule, pus and blood, owing to the frequent co-existence of cystitis.

[In some cases the repeated appearance of very large cells with gigantic nuclei, or with two, three, or more nuclei, often of unequal size, should excite strong suspicion, more specially if the presence of these cells is associated with repeated hæmorrhages and vesical pains. A persistent search for masses of cells sufficiently large to make diagnosis certain will generally be successful. The editor has followed one case of carcinoma of the bladder for over two years, and found that such cells were almost constantly present, whilst villous masses and other shreds of tumours appeared only at times. At the *post-mortem* examination, the walls of the bladder were found considerably thickened, being almost entirely

replaced by carcinomatous tissue, the tumour had extended laterally as far as the parietes of the pelvic cavity. At one place only, long villi projected from the walls into the cavity of the bladder. In three other cases, one of which was also examined *post-mortem*, the presence of similar cells had been ascertained during life, and their presence had led to further search, which, in each case, had ended in the discovery (sometimes after several weeks) of typical shreds of tumour tissue.

In ulcerating epitheliomata or papillomata of the bladder the epithelial cells often become much elongated, and may appear in the urine as bundles of spindle cells. This appearance might lead to an erroneous interpretation, and to a diagnosis of spindle celled sarcoma.

Fig. 16.—Cells from a Carcinoma of the Bladder (× 200). The tumour was ulcerating, and these cells were repeatedly found in the urinary sediment.

In Fig. 16 are represented some cells, isolated and in small groups, found in the urine of one of the cases mentioned above]

The villi represented in Plate XVI., Figs. 5 and 6, and Plate XVII., Fig. 6, were voided after the passage of a catheter. In this case the use of the catheter always resulted in the tearing off of some shreds of tumour.

Plate IX., Fig. 1, represents shreds of tumour found in the urine of a woman suffering from primary carcinoma uteri, which had extended to, and invaded, the bladder. There was no jaundice and no bile pigments in the urine; there were traces

of blood. Among the polymorphous cells of the carcinomatous tissue there were tufts of acicular crystals, and a few rhombic plates of hæmatoidin. Neoplasms of the kidney cannot, as a rule, be diagnosed by microscopic examination of the urine.

[A case of renal sarcoma, diagnosed by the editor during the life of the patient, is referred to in connection with casts of the ureter on p. 68.]

Vegetable Micro-organisms in the Urine.

The urine, particularly when the external temperature is high, forms a very favourable medium for the development of many bacteria, some of which are the causes of its decomposition (see sections on *Acid and alkaline fermentations of the urine*, p. 89).

Bacteria, yeasts, or moulds are never found in the fresh urine of a healthy individual, but occur frequently in disease.

Bacteria may be introduced into the urinary passages by means of unclean catheters, or they may pass along the urethra into the bladder, more specially when there is paralysis of the sphincter vesicæ and constant dribbling of urine. They may then give rise to a very considerable *turbidity*, or even to a distinct sediment in the urine. Bacterial *turbidity* differs from others in not being altered by acids, alkalies, or heat, by the impossibility of obtaining the urine clear on sedimentation or filtration. Bacteria stain readily with aniline dyes. Under the microscope they are readily recognised by their shape, uniform size, and the motility displayed by many of them.

[The reader will notice that the drawings of bacteria given in this atlas are, in many cases, meant to give a general impression of the appearances presented by these organisms rather than absolutely accurate representations of their shape and relative size.

A complete account of the bacteriology of urine would be out of place in a work which does not deal with bacteriological methods proper; the reader must therefore be referred to bacteriological treatises for a full account of this subject. With regard to the *passage of pathogenic bacteria* through the kidney, Prof. C. S. Sherrington's article in the *Journal of Pathology and Bacteriology*, vol. i., p. 258, should be consulted.]

Bacteria (*Schizomycetes*).

Bacteria of Ammoniacal Fermentation [Uro-Bacteria].

Micrococcus and Bacterium ureæ (so called).

(Plates XVIII., XIX., and XX.)

Urine in a state of ammoniacal fermentation always contains bacteria, among which may be mentioned the so-called *Bacterium ureæ* (Plate XIX., Fig. 1, and Plate XX., Fig. 2), which, as a rule, is somewhat shorter and thicker than the tubercle bacillus, and the *Micrococcus ureæ*, which often forms chains (Plate XVIII., Fig. 5).

The delicate iridescent pellicle which forms on the surface of alkaline urine, contains these micro-organisms in great abundance, or may even entirely consist of them. Some of the bacilli (generally short rods as in Fig. 2, Plate XX.) and cocci exhibit active motility; they belong to several bacterial forms as was first shown by *Leube*.

[A *Micrococcus ureæ* was first described by *Pasteur* and more completely studied by *Van Tieghem*; since then a large number of organisms have been found to be capable of causing the same fermentation; *Leube* has described a sarcina; *Flügge*, a micrococcus; *Miquel*, several bacilli, and other micro-organisms.]

Under their influence urea is transformed into ammonium carbonate, which gives the urine its alkaline reaction; for alkaline fermentation of the urine, see p. 89).

Sarcinæ.

(Plate XXI., Fig. 1.)

The sarcinæ found in urine are, as a rule, smaller than the *Sarcina ventriculi*, and have been called *Sarcina urinæ*. They appear in the form of cubical masses, subdivided into four smaller cubes each composed of four cocci; large packets may be formed by the combination of a number of cubes. They are found in acid, neutral or alkaline urines, but more especially in the latter. They have no pathological significance. [According to *Leube* there is a sarcina capable of causing ammoniacal fermentation of urea.]

Bacillus Tuberculosis.

(Plates XVIII. and XIX.)

A few isolated tubercle bacilli may be found at times in the urine in general miliary tuberculosis.* They are, on the contrary, frequently present in cases of local tuberculosis of the *genito-urinary* apparatus (kidney, bladder, prostate, and testis) when caseous degeneration and ulceration have occurred. In these cases the presence of tubercle bacilli is of great diagnostic significance. The following remarks will, therefore, refer to the forms of tuberculosis effecting primarily the genito-urinary organs. As a rule, the demonstration of tubercle bacilli in the urine requires careful and repeated examination of the sediment obtained by centrifugalisation (Plate XVIII., Fig. 6). Occasionally, however, the bacilli are present in such large numbers that they are readily found on microscopic examination of the sediment deposited in the usual way. The abundance of bacilli in such cases generally depends on the detachment of fragments of caseous matter which pass into the urine.

As a rule, the localisation of the tuberculous process can only be made out from the accompanying symptoms. The presence of casts and of other products of renal origin indicates the probability of the kidney being involved.

Failure to find tubercle bacilli does not exclude the possibility of the existence of tuberculosis of the genito-urinary organs.

[* See the case recorded by Philippowicz, *Wiener med. Blätter*, vol. xxxiv., pp. 673, 710, 1885.]

Urine containing tubercle bacilli is albuminous in various degrees, and remains acid so long as the bladder has not been invaded by bacteria capable of causing alkaline fermentation, which is very liable to occur when the tuberculous process involves the walls of the bladder.

To urines containing deposits of urates and phosphates, it is advisable to add *Sehlen's* reagent (borax 4, boric acid 4, and water 100 parts) before sedimentation.

To obtain suitable microscopical preparations small portions of the sediment are spread on coverglasses, dried, fixed, and stained according to the *Ziehl-Neelsen* method.

Tubercle bacilli may be distinguised from smegma bacilli, by treating the specimen with alcohol after decolourising in acid, when the smegma bacilli are promptly decolourised.

[To prevent the smegma bacillus staining like the tubercle bacillus, several observers have recommended that, before staining them, the films should be left for ten minutes in a warm solution containing 10 per cent. of soda and 5 per cent. of alcohol. The editor has for the last fifteen years used successfully the following method:—The sediment, after being spread and fixed on a coverglass, is washed, first in water, preferably hot, to remove the soluble salts, then in a mixture of equal parts of alcohol and ether, which, after about two hours, is heated to the boiling point of ether; the films are then washed rapidly with absolute alcohol, and are ready for staining. It is, however, usually easy to obtain very clear preparations, by treating the urinary sediment exactly as sputum would be; in good preparations the smegma bacillus is very rarely a source of difficulty. It is preferable to wash the films after fixing them.]

Tubercle bacilli stained according to this method appear as red rods on a blue background (Plate XVIII., Fig. 6; Plate XIX., Fig. 1). They are often aggregated in large masses, which at times are large enough to form red patches visible under a low power of the microscope.

Tubercle bacilli may find their way into the urine along with the fæces in cases where a fistulous communication exists between the alimentary and urinary passages.

[When there is ulceration of the bladder, large masses of bacilli arranged in typical bundles similar to those observed in pure cultures on serum may be found in the urine. The bacilli in such cases may acquire a considerable length, and be branched. Genito-urinary tuberculosis is often overlooked, though a careful bacteriological examination of the urine should make its diagnosis comparatively easy. The following cases illustrate this:—

In one case, the symptoms simulated those of renal lithiasis; the patient was being prepared for the operation of nephrotomy (a chemist, to whom the urine was usually sent for examination, had discovered in it peculiar bodies, which were supposed to be microscopical calculi). A specimen of that urine was sent to the editor for confirmation of the diagnosis, and he found in the fluid purulent shreds of necrosed tissue, suggesting the possibility of tuberculous

ulceration. This led him to examine the sediment for tubercle bacilli, which he found in very large numbers. (The bodies which had been supposed to be minute calculi were only Lycopodium spores. On enquiry it was found that the patient had been in the habit of using Lycopodium powder, for the purpose of allaying irritation of the vulva.) The further symptoms and development of the disease entirely confirmed the microscopical diagnosis.

Another equally interesting case was that of a young man who had been operated upon for the removal of a renal calculus. No stone could be found, but the operation brought considerable relief to the patient. The operation wound, however, healed very slowly. After an interval of several months, renal colic recurred, and a second operation was considered advisable. Previous to this the urine was submitted to the editor for microscopical examination. There was nothing in the symptoms of the patient suggesting the existence of tuberculosis, but the results of the first operation had created suspicion.

The urine was almost clear, slightly acid, very slightly albuminous, and had a specific gravity varying between 1017 and 1020. By centrifugalisation a very scanty sediment was obtained, composed chiefly of leucocytes, epithelial cells from the bladder and possibly the ureters, and a very large number of staphylococci, many of them enclosed in leucocytes. No crystals or inorganic particles of any kind could be discovered. Three microscopical preparations were examined without a single typical tubercle bacillus being found; but a few granules staining red were found in each specimen. These granules, cocci like, sometimes in pairs or in small groups, are often found in tuberculous urines; the search was therefore persisted in. In a fourth specimen one typical bacillus was found. Finally, after examining two or three more films, an unmistakable group of eight or ten bacilli was found.

Taking into account the pain experienced by the patient in the region of one kidney, the duration of the illness, the small amount of cells and albumen in the urine, the intermittent presence of *Staphylococcus pyogenes aureus* and of the tubercle bacillus in the fresh urine, the quantity of urine, which was about normal, also the absence of vesical symptoms, the editor arrived at the conclusion that there was tuberculosis of one kidney and ureter, complicated with partial obstruction of the ureter, pyelonephritis and nephrosis.

The diseased kidney, as well as the upper part of the ureter, were, in consequence, removed by Professor T. Jones, and found, by complete examination of the parts removed, to be exactly in the state just described. The patient made an excellent recovery, the wound this time healing rapidly.]

Gonococcus.

(Plates XVIII. and XIX.)

Gonococci, the demonstration of which is of great practical significance, are found in the purulent sediment occurring in recent cases of gonorrhœal urethritis, and also in gonorrhœal inflammations of the uterus and tubes.

Pyogenic cocci are also frequently found in such cases, especially when purulent cystitis coexists; sometimes, indeed, pyogenic cocci alone are found. For the demonstration of gonococci, coverglass preparations of the sediment are prepared in the usual way, *i.e.*, some of the pus is squeezed between two coverglasses which are afterwards separated, or some of the pus is taken with the looped needle and spread on coverglasses; after allowing the thin films thus obtained to dry completely, the coverglass is passed three times through the flame of a Bunsen burner, or of a spirit lamp. The film being fixed, is stained for several seconds in a concentrated watery solution of one of the basic aniline dyes—*e.g.*, methylene blue, fuchsin, gentian-violet; the film is then washed in water and examined immediately in a drop of distilled water, or, after washing, it may be dried and mounted in balsam.

Gonococci (Plate XVIII., Fig. 4; and Plate XIX., Fig. 2), as seen under a high power (preferably a $\frac{1}{12}$-inch oil-immersion objective), are diplococci; each coccus is flattened on the side which is in contact with its companion. The appearance produced by this arrangement has been compared with that of a coffee bean or of two haricot beans or kidneys placed side by side with their concave borders opposed and separated by a small chink. Occasionally they form tetrads.

They occur free between cells (occasionally aggregated in small groups), but in the early stages most of them are contained in the protoplasm of pus-corpuscles, where they are found in small groups (never chains); they often entirely fill the cell-body. The nuclei always remain free. This intracellular disposition of the gonococci is very characteristic, as is also their avidity for the aniline dyes.

They are decolourised by Gram's method. This property of the gonococci is important as distinguishing them from pseudo-gonococci.

Gonococci are also found in the urethral threads, which have already been described (p. 64) as occurring in the urine in gonorrhœal urethritis.

[Great caution should be exercised in the diagnosis of gonorrhœa. Simple microscopical examinations, when the gonococcus of Neisser is not abundant and not enclosed in cells, should be confirmed by cultivation tests. Various methods of cultivation have been devised by Wertheim, Turro, Král, &c.]

Other Pathogenic Schizomycetes.

Generally speaking, the following bacteria cannot be recognised accurately without the assistance of cultivation methods, they will, therefore, be dismissed somewhat briefly, and for further information the reader is referred to bacteriological text-books.

Staphylococci and Streptococci.

(Plates XIX., XXI., and XXIV.)

Pyogenic bacteria—*i.e.*, staphylococci (*e.g.*, *Staphylococcus pyogenes aureus*), aggregated into groups and grape-like masses (Plate XIX., Fig. 4), and streptococci (*e.g.*, *Streptococcus pyogenes*) arranged in chains (Plate XXIV., Fig. 1, and Plate XXI., Fig. 2)—are found in the urine in suppurative inflammations of the kidney (embolic nephritis, suppurative pyelo-nephritis) and of the urinary passages, especially cystitis. They may also be found when abscesses of neighbouring organs rupture into the urinary passages. They are generally associated with the presence of pus. Not infrequently suppurative

inflammations are only complications of other lesions of the urinary organs—*e.g.*, scarlatinal nephritis (Plate XXIV., Fig. 1). In erysipelas, streptococci are occasionally found in the urine, and in endocarditis and osteomyelitis the *Staphylococcus aureus* may be present.

Bacillus coli communis.

(Plates XXI. and XXIV.)

The *Bacillus coli communis*, coming originally from the intestine, is frequently found in the urine in various morbid conditions of the urinary apparatus, in scarlatina nephritis (Plate XXI., Fig. 2, and Plate XXIV., Fig. 1), cystitis, &c. It varies in size, but, as a rule, forms short slender rods, frequently arranged in pairs, occasionally in chains and larger groups (Plate XXIV., Fig. 1). It can be recognised with certainty only by cultivation. It stains readily with ordinary aniline dyes, but is decolourised by Gram's method.

Typhoid Bacillus.

Typhoid bacilli have been found by various observers in the urine of patients affected with typhoid fever. Their presence can be demonstrated only by means of cultivation.

> [The typhoid bacillus is seldom found before the end of the second week of the fever. The presence of these bacilli in the urine is associated with albuminuria, but albumen may be present in the urine without the bacilli.]

Spirillum of Relapsing Fever and Glanders Bacillus.

The spirilla of relapsing fever occur very rarely, and only when the disease is complicated with hæmorrhagic nephritis. The same may be said with regard to the bacillus of glanders.

Leptothrix buccalis.

This organism is of rare occurrence; it has been occasionally met with in diabetic urine, and probably comes from the preputial sac.

In addition to the above-mentioned bacteria, many others (pathogenic and non-pathogenic) may be found in the urine; thus, large bacilli (Plate XIX., Fig. 3) are of frequent occurrence.

When bacteria are present in the urine in great abundance they may be aggregated together in cylindrical masses. (For *Bacteria casts* and *Pseudo casts* see p. 73.)

Actinomyces Granules.

In actinomycosis (primary or secondary) of the urinary organs this parasite may be found in the urine in the form of small, yellow, gritty particles along with purulent débris. (Very rare occurrence. See *Grainger Stewart's* case *Edinburgh Hosp. Rep.*, vol. i., 1893.)

So-called Idiopathic Bacteriuria.

Occasionally, freshly voided urine is turbid from the presence of bacteria. Microscopic examination of the sediment obtained by centrifugalisation reveals numerous pathogenic bacteria and, particularly, staphylococci (Plate XIX., Fig. 4); in contrast with other bacteria-containing urines, leucocytes, and cells from the urinary passages are very scanty. The urine as regards colour, odour, and other characters is quite normal.

> [The editor has observed several cases in which the urine, on being voided, was turbid, owing to the presence of micro-organisms; in one case, the *Bacillus coli communis* was found to be the only organism present; the patient was dying of carcinoma of the liver. During the last stages of exhausting diseases bacteria pass through the kidney perhaps more frequently than is generally suspected. It is probable that most cases of so-called idiopathic bacteriuria may be explained by the existence of some important lesion, not always of the kidneys. Various experimenters and observers have proved the possibility of a passage of bacteria through the kidneys in the absence of any gross lesion. See *Sherrington*.]

Yeasts (*Blastomycetes*).

Torula, Saccharomyces urinæ.

(Plates XX. and XXI.)

These fungi, which multiply by budding, have no pathological significance. They occur as smooth, highly-refractive, oval cells, which may reach the size of leucocytes, but are usually smaller; they are either isolated, arranged in rosary-like chains, or in clumps (Plate XX., Fig. 3). Buds in process of constriction may be frequently seen attached to the larger cells. Isolated yeast cells are frequently found in urine which has been exposed to the air for some time, and which is undergoing acid fermentation, a change of which they have been said to be the cause (Plate XXI., Fig. 5, see p. 89).

Yeasts do not thrive well in urine free from sugar, but they grow rapidly in diabetic urine. In such cases they appear as large cells sometimes elongated and in the shape of filaments; they are not infrequently present in freshly voided urine, but occur more especially in urine undergoing fermentation, where they cause splitting up of the sugar with formation of carbonic acid gas.

Their presence in large quantity in the urine suggests the existence of glycosuria.

> [The editor has observed two cases of diabetes mellitus in which these fungi had penetrated into the bladder and continued to multiply there. The urine was turbid when voided, and, at times, effervescent.]

Yeast cells may be distinguished from leucocytes by the presence of buds, by their sharp outline, their greater refractivity, and by the absence of fine granulations and nuclei. After the addition of acetic acid the saccharomyces remains unaltered, whilst the leucocytes become more transparent and their nuclei more distinct (Plate XIV., Fig. 5).

Saccharomyces albicans.

Oïdium [*Saccharomyces*] *albicans* (*Thrush fungus*) is rarely found in the urine, where it is carried from the vulva or vagina.

Moulds (*Hyphomycetes*).

(Plate XX., Figs. 4, 5, and 6; Plate XXI., Fig. 3; Plate XXIV., Fig. 6.)

If urine is allowed to stand exposed to the air for some time, it may become contaminated by the spores of various hyphomycetes which are present in the air. The development of these organisms in the urine has no clinical significance.

The *Penicillium glaucum*, with its large branching mycelia (Plate XX., Fig. 4), is most frequently found; the spores, rounded in form, are remarkable for their size; occasionally they are covered with a layer of urates which gives them a brownish colour, and not infrequently they may be found in a state of germination, when they have a club-like form.

When putrefaction succeeds alcoholic fermentation in a diabetic urine, moulds appear in abundance and form a dense white pellicle on its surface.

Moulds and yeasts are often difficult to distinguish from one another, except by cultivation, and particularly so when they are undergoing involution, as frequently happens in the urine.

Animal Parasites.

Hydatid Cysts, Tænia Echinococcus.

Hooklets and fragments of the cysts of echinococcus (Fig. 17), or whole daughter cysts (scolices), may be voided with the urine in cases of hydatid disease of the urinary passages and kidneys, or when a cyst located in a neighbouring organ ruptures into the urinary passages. The *clear* transparent daughter cysts may contain one or several scolices; their walls show a characteristic laminated structure similar to that of the parent cyst; when torn these membranes have a tendency to roll up. In addition to fragments of the parasite the sediment contains red blood-corpuscles, leucocytes, and

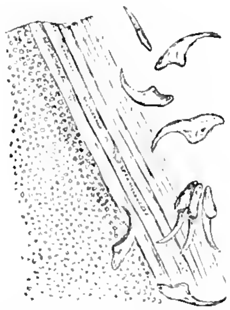


Fig. 17.—Echinococcus Hooklets and Membrane of Hydatid Cyst (after *v. Jaksch*).

Fig. 18.—*Filaria sanguinis hominis* (after *Lewis* and *Leuckart*).

other cellular products. The appearance of such fragments in the urine may be preceded by symptoms of renal colic.

[In one case recorded by *Barker*, 150 small hydatid cysts were found in the urine. The occurrence of hydatid cysts in the kidneys, genital organs, and pelvic cavity is less unfrequent than is generally supposed; out of 1759 cases of hydatid disease collected by *Davaine*, *Böcker*, *Neisser*, *Finsen*, *Madelung*, and tabulated by *Blanchard*, these organs were affected 262 times—*i.e.*, in over 14 per cent. of the cases; in 123, the cysts were in the kidney. The passage of hooklets or portions of cysts in the urine is, however, of great rarity.]

Filaria sanguinis.

In cases of tropical hæmaturia and chyluria [occurring in India, Egypt, Australia, Brazil, Guadaloupe, &c.], the embryos of *Filaria sanguinis* (Fig. 18) are frequently found in the urine; they are slender organisms lying in a delicate sheath, and generally actively motile.

[This parasite was discovered in chylous urine in India by *Lewis*, even before he had recognised its occurrence in the blood; the presence of this worm in the urine is chiefly due to its lodgment in the kidneys. The chyluria is due to

obstruction of abdominal lymphatics; the hæmaturia, to rupture of capillaries in the kidneys. The editor found in a case which he had under observation in London, that the number of filariæ in the urine was proportionate to the amount of blood in that fluid, but not to the amount of fat; the parasite, though abundant in the blood at night, was often absent from the urine. The patient had been in India.]

Distoma hæmatobium.

The eggs of this parasite (Fig. 19) are found in the urine along with blood, pus, and fat in cases of endemic hæmaturia or Bilharziosis [this disease is common in Egypt, Abyssinia, the Cape, and various parts of the Eastern Coast of Africa]; they are oval bodies about 0·12 mm. long and 0·05 mm. broad, with granular contents and a small terminal or almost terminal spine; they occur free or enclosed in flocculent matter, and are especially abundant in blood clots.

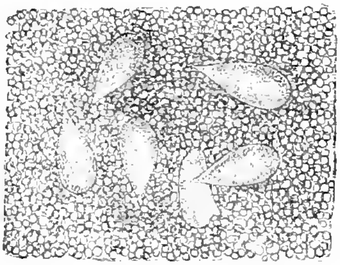


Fig. 19.—Eggs of Distoma hæmatobium in Sediment (after *v. Jaksch*).

[Among the eggs present in the urine some may be found in which the embryo is fully developed and ready to escape. In the case of a patient who had recently returned to England from Egypt the editor was able to observe embryos in a state of active motion; he did not wituess the escape of these embryos, but *Zancarol* states that the free embryo may be found in the urine. *Cobbold* noticed that the escape of the embryo takes place very much more slowly in urine than in pure water.]

Strongylus gigas.

Strongylus gigas, the palisade worm, is a round worm very rarely met with in the renal pelvis; it may be the cause of pyuria and hæmaturia. The eggs are brownish oval bodies with a foveolated capsule.

[There are not a dozen genuine cases on record in which this worm has been observed in the kidney after death, and the presence of the worm or of its eggs in the urine must be of extraordinarily rare occurrence.]

[*Ascaris lumbricoides, Oxyuris vermicularis, Rhabditis genitalis.*

These round worms have been found, in a few cases, as a result of the mixture of fæcal products or of discharges from the vulva with the urine. In some cases the contents of the intestine had passed into the urinary passages through a fæcal fistula.]

Infusoria.

Cercomonas seu Bodo urinarius.

(Figured by Eichhorst (*Lehrbuch der klinischen Untersuchungsmethoden*), and others.)

This protozoon is occasionally found in alkaline urine, especially from cases of cholera: it appears to have no pathological significance. It consists of a small rounded or oval body, somewhat smaller than a leucocyte—namely, 12 μ long and 7 μ broad—which contains a nucleus in its anterior part, and is provided at its anterior extremity with a pair of flagella, by means of which it can travel with startling rapidity. It multiplies by fission.

Trichomonas vaginalis.

(Figured by W. Janowski, *Zeitschrift für klinische Medicin*, Bd. 31, 1897.)

This organism is occasionally found in the urine of females in consequence of its admixture with vaginal mucus. It has also been met with in a few cases in the urine of males, when it probably came from the urethra. It is an oval organism with an average length of 14 μ. Anteriorly, it is provided with one to three flagella-like processes; the body is traversed by a sinuous furrow along one side and, posteriorly, it terminates in a spine-like process. It is actively motile and has no pathological significance.

[Other *Infusoria* and *Amœbæ*, may be derived from the intestine or more usually from dirty water, when such has been used for washing the vessels in which the urine is received.

Pediculi, *Fly larvæ*, *Acari* have also been found occasionally in the urine.

The so-called "*Acarus farinæ*" and its eggs are at times found abundant in the urine. They are sometimes derived from rice or other powders used by patients. At other times they are abundant in unfiltered water or water kept in open cisterns, and may thus find their way into any vessel washed with such waters. Their presence is of no practical importance, but, as they resemble the *Acarus scabiei*, a superficial microscopical examination of a sediment might lead to an erroneous diagnosis. The accompanying figure (Fig. 20) represents one of these

Fig. 20.—*Acarus farinæ* and its egg (× 200).

acarids observed by the editor in the urine of a female patient affected with glycosuria and pruritus vulvæ. This person was in the habit of using rice powder for the purpose of relieving the latter symptom. There was in the same urine an abundant sediment of starch granules; the acari were very numerous in the deposit.]

III. ACCIDENTAL CONTAMINATIONS OF URINARY SEDIMENTS.

In spite of care and cleanliness it is often impossible to avoid the contamination of the urine with extraneous products. It is, therefore, well to be acquainted with the most common of these contaminations, in order that no undue importance be attached to them.

Textile Fibres.

These fibres may be confused with urinary casts by beginners only; they are derived from the clothes of the patient, the towels or dusters employed to clean the apparatus used, or from the dust floating in the air.

Cotton Fibres.

(Plate XXXVI.)

Microscopically, they present the form of flattened ribbon-like tubes of various lengths, frequently twisted in a cork-screw fashion and gradually becoming thinner towards one end.

Flax Fibres. Linen.

(Plate XXXVI.)

These fibres are seen, microscopically, to consist of very thick-walled tubes with a very small lumen; in section they are circular, polygonal, or flattened, and, occasionally, provided with nodular swellings. In the nodes, irregular fractures are sometimes to be seen. Old fibres coming from cloths which have been frequently washed are fissured longitudinally and have irregular and indefinite contours.

Silk.

(Plate XXXVI.)

Silk consists of cylindrical, shining, homogeneous threads composed of two filaments which occasionally show a slight spiral twist. On the addition of sugar solution and sulphuric acid they assume a pink colour and are rapidly dissolved.

Wool.

(Plate XXXVI.)

By treatment with strong caustic potash wool fibres become brownish-red and translucent; after the addition of sugar solution and sulphuric acid wool takes a pink colouration, but less rapidly than silk. In the long axis of each fibre, as in the hairs of all mammals, the medulla may be seen. The fibres are covered with irregular, cuticular, imbricated scales.

Hairs.

(Plate XXXV.)

They vary in thickness and are usually pigmented; their structure is not evident before the addition of caustic alkalies; the epidermic scales are usually less evident than in the hairs composing wool. Pubic hairs are very thick.

Feather Barbs.

(Plate XXXV.)

They consist of a stem becoming gradually thinner towards one end and provided with lateral pointed processes.

Starch Grains.

(Plate XXXV.)

These are bright, irregular, oval or circular bodies; easily recognised, as a rule, by their concentric lamellation.

Their nature may be placed beyond doubt by the blue colour which they assume when treated with iodo-potassic iodide solution. They are found especially in the urine of young infants [but are also occasionally found in large quantities in the urine of women.]

Fat.

(Plate XXXV.)

Fat frequently finds its way into the urine in consequence of the use of catheters; but it may also occur in connection with disease. (See section on *Fat and fatty crystals*, p. 45).

Fat globules are characterised by their sharp, dark contour and clear centre; they do not refract light so strongly as spherical air-bubbles.

Fat globules are blackened by a 1 per cent. solution of osmic acid, and are stained scarlet-red by an alcoholic solution of Sudan III.

Air-bubbles.

(Plate XXIV.)

They are very variable in size. As a rule they appear circular in form, but when compressed are extremely irregular. When spherical they may be recognised by their dark double or multiple outlines and clear bright centres.

When air penetrates a microscopical preparation in consequence of drying, it forms flattened and irregular strands with thin outlines (left side of figure).

Excrements.

Constituents of the faeces are met with in the urine in cases of incontinence of faeces, and where abnormal fistulous communication exists between the bladder and rectum.

[In the latter case, gases often escape from the bladder when the urine is voided. The discovery of faecal constituents, such as *partly digested muscular fibres* and *vegetable tissues* in the urine, indicates a *fæcal fistula*, when proper care has been taken to receive the urine direct from the urethra.]

IV. CHARACTERS OF URINARY SEDIMENTS IN NORMAL AND PATHOLOGICAL CONDITIONS.*

Sediment of Normal Acid Urine.

When healthy urine is allowed to stand for a few hours (or when it has been centrifugalised for a few minutes), it deposits a transparent, filmy cloud of mucus, the so-called "nubecula," which, on microscopical examination, is found to contain isolated epithelial cells from the urinary passages, leucocytes, and some amorphous and crystalline salts (see pp. 2 and 62). Under certain physiological conditions, as increased metabolism, excessive muscular exertion, the acidity of the urine is increased, and pure crystals of uric acid may also be deposited. In females the epithelial constituents of the sediment are more abundant than in males, owing to the presence of cells derived from the vulva and vagina.

If the urine has a neutral reaction when voided, or if it is allowed to stand for some time, the sediment may contain, in addition to the organised elements, amorphous tricalcium and trimagnesium phosphate, and crystals of dicalcium phosphate. When the urine has an alkaline reaction when voided (*e.g.*, after the ingestion of large quantities of vegetables, during digestion, after warm baths), the sediment may contain all the salts (calcium carbonate, ammonium urate, ammonio-magnesian phosphate, &c.), which are usually precipitated abundantly during alkaline fermentation of the urine.

Urine of New-born Children.

(Plate XXI.)

The urine of a male child may be collected in a test-tube or indiarubber finger-stall fixed to the body in a suitable fashion.

The sediment may contain amorphous salts; scales of dicalcium phosphate; thick, irregular, five- and six-sided plates of uric acid; yeasts and moulds (Plate XXI., Fig. 4); starch grains (from dusting powder); epithelium; and, lastly, ammonium urate casts.

[* The editor has considered it best to let the author alone speak in this chapter, which consists almost entirely of the matter contained in the previous parts, re-arranged according to diseases or lesions.

It has been thought, however, unnecessary to reproduce descriptions occupying several pages, and which were almost verbatim duplicates of those which the reader will find opposite the plates. A few synonymous terms have been added to make the nomenclature used by the author clearer to English readers.

The editor has in the previous pages expressed his own views regarding the nature and the diagnostic value of some of the products entering into the formation of urinary sediments.]

Acid Fermentation.

(Plate XXI.)

When healthy urine is kept in clean covered vessels, in a cool place, its acidity gradually increases for several days.* This change, which is associated with turbidity and darkening of the urine, is termed "acid fermentation," and appears to be due to the development of certain fermentation fungi. After several days (in some cases only after several weeks) this form of fermentation gives place to alkaline fermentation.

Urine undergoing acid fermentation shows under the microscope (Plate XXI., Fig. 5) yellowish crystals of uric acid of various sizes and forms, crystals of calcium oxalate and fungi (*Torula*, *Saccharomyces urinæ*), isolated or arranged in short chains; and, occasionally, amorphous masses of acid sodium urate.

Alkaline Fermentation.

(Plates XXI. and XXII.)

Ammoniacal fermentation may occur in any kind of urine which has been exposed to the air for some time, and may be preceded or not by the acid fermentation; it is accelerated by warmth. The time of appearance and the duration of the acid and of the alkaline fermentations are very variable, and depend on the external temperature and on the composition of the urine.

During the hot seasons of the year ammoniacal fermentation may occur within a few hours, but it may be delayed for several days when the temperature is low. Urines containing pus and blood seem particularly prone to decomposition, specially when they are kept in dirty vessels.

At times the urine is already in a state of ammoniacal fermentation when voided, this occurs specially when non-sterile catheters and sounds have been previously passed into the bladder; in other cases this change occurs with extraordinary rapidity after the urine has been voided, and frequently without assignable cause.

Normal urines may be of alkaline reaction after the ingestion of alkaline carbonates and of the salts of vegetable acids; they are readily distinguished from ammoniacal urines by not giving rise to a cloud of ammonium chloride when a rod dipped in hydrochloric acid is brought over them, and by giving to litmus a permanent blue colour (fixed alkalies). During ammoniacal fermentation the urine, under the influence of micro-organisms (*Micrococcus* and *Bacillus ureæ*, and other bacteria), becomes pale yellow, strongly alkaline, and emits a penetrating ammoniacal odour; this is due to the conversion (by hydration) of urea into ammonium carbonate, which unstable salt continuously gives off free ammonia. The urine becomes gradually more turbid, and, finally, a greyish-white sediment is deposited, which consists of ammonio-magnesian phosphate (coffin-lid crystals, Plate XXI., Fig. 6; Plate XXII., Figs. 1 and 2); to which, sooner or later, ammonium urate is added in the form of smooth yellow spheroids, hedgehog masses, dumb-bells (Plate XXI., Fig. 6), needles and small prisms (Plate XXII., Fig. 2); also amorphous masses of tribasic calcium phosphate (Plate XXI., Fig. 6; Plate XXII., Fig. 1), and granules or crystals of calcium carbonate (Plate XXII., Fig. 1). The bacteria causing the fermentation of urea and other micro organisms are abundant in the urine, and may accumulate in the sediment when the fermentation has existed for some time. (Any uric acid crystals or amorphous acid urates which may have been present in the urine before the onset of the alkaline fermentation undergo gradual solution.)

Spermatorrhœa.

(Plate XIV.)

The urine generally has an unpleasant smell and is turbid, and resembles urine containing mucus or bacteria (Bacteriuria). In the sediment (Plate XIV., Fig. 3) are found spermatozoa, leucocytes, and urinary salts (amorphous urates, triple phosphate, &c.), and, occasionally, small round epithelial cells (derived from the testis).

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* With regard to the duration of acid fermentation and the influence of temperature, &c., see *Alkaline fermentation*.

Vaginitis.

(Plate XII.)

The presence of small white flocculi, visible to the unaided eye, and consisting of coherent layers of squamous epithelium (Plate XII., Fig. 6), is very characteristic of this condition. Occasionally fat globules and fatty acid needles are found on these cells. In addition to these epithelial cells, leucocytes are generally found in large quantity in the urine. The microscopic demonstration of gonococci in the urine, vaginal or urethral discharges in cases of *gonorrhœal vaginitis and urethritis* is of great diagnostic importance.

Acute Cystitis.

(Plate XXIII.)

The urine is generally acid, rarely alkaline in reaction: it appears turbid, and contains an amount of albumen corresponding to the quantity of pus present. The sediment contains vesical epithelium, red and white blood-corpuscles. The red blood-corpuscles are decolourised; the nuclei of the epithelial cells and of the leucocytes are frequently stained with blood pigment (Plate XXIII., Fig. 1). When the urine is acid, the sediment is generally granular and flocculent.

Chronic Cystitis.

(Plate XXII.)

The urine is generally alkaline, rarely acid in reaction; it is turbid and has an offensive, penetrating smell, in consequence of the presence of ammonium carbonate; it always contains albumen and mucin.

The sediment appears as a viscid, ropy, gum-like, gelatinous mass difficult to tease. On microscopic examination it is found to contain mucus, swollen fatty vesical epithelium, crystals of acid ammonium urate and ammonio-magnesian phosphate (the latter being particularly abundant), amorphous earthy phosphates, numerous bacteria, often forming large masses, many pus-corpuscles, the majority of which are undergoing disintegration. The granular débris also frequently contain albuminous granules and fat globules (Plate XXII., Figs. 3 and 4).

Hæmaturia.

(Plate XV.)

The term *Hæmaturia* implies a condition in which the urine contains red blood-corpuscles as opposed to *hæmoglobinuria*, in which the urine contains the blood pigment in solution or precipitated, and no blood-corpuscles.

The colour of the urine in hæmaturia varies according to the number of red blood-corpuscles or the amount of blood pigment present, from the colour of meat juice to a dark brown.

Red blood-corpuscles are found in the urine in hæmorrhages due to extreme passive congestion, hæmorrhagic diathesis, injury, inflammation of the urinary passages and kidneys, and the presence of tumours. In fresh urine they may appear normal in form, size, and colour, but readily undergo change when allowed to remain in the urine (Plate XV., Fig. 4); further, they never form rouleaux. In severe hæmorrhages no other formed constituents than red blood-corpuscles are, as a rule, found in the urine.

Vesical Hæmorrhage.

In vesical hæmorrhage the urine contains numerous red and white blood-corpuscles and epithelial cells derived from the vesical mucous membrane; after standing some time—that is, in the early stages of alkaline fermentation—it may also contain a few crystals of triple phosphate.

The presence of large blood or fibrin clots generally indicates hæmorrhage from the urinary passages.

If the blood is voided with the last portion of the urine, this usually indicates a vesical origin, since the blood whilst in the bladder subsides to the most dependent parts.

A bright red colour, an alkaline reaction, and a small amount of albumen in the urine, also point to vesical hæmorrhage.

Urethral Hæmorrhage.

Hæmorrhages from the urethra are, as a rule, insignificant. The urine is not coloured by the blood, but the last few drops voided may consist almost entirely of blood.

[This statement of the author applies only to a certain class of cases. "Blood from the urethra usually flows independently of micturition, as in recent injuries; or passes with the first few drops of urine. It may, however, occasionally come with the last few drops expelled," as in gonorrhœa, granular conditions of the bulbous portion of the urethra, as a consequence of the contraction of the ejaculator urinæ.—*Erichsen.*]

Renal Hæmorrhage.

(Plate XXII.)

In renal hæmorrhage the urine has a greyish-brown or reddish-brown colour [smoky urine]; it is dichroic, acid in reaction [in uncomplicated cases], and markedly albuminous. Since the blood is intimately mixed with the urine, the whole of the latter has an uniform hæmorrhagic appearance.

The biconcave form of the red blood-corpuscles is often remarkably distinct (Plate XXIII., Fig. 2); they may, however, present considerable variations in size and form, some being small and shrivelled, many crenated. Sometimes they are swollen and deprived of their colouring-matter, appearing as shadowy stromata; in other cases they are completely disintegrated, being reduced to clumps and rounded granules containing more or less hæmoglobin.

As in vesical hæmorrhage, the blood constituents are often accompanied by other structures which may have important diagnostic significance. Thus a characteristic feature of renal inflammation is the occurrence of casts covered with red and white blood-corpuscles or of cells which have taken up red blood-corpuscles into their substance. The absence of large blood-clots from the urine is a point in favour of the renal origin of the hæmorrhage.

Blood-corpuscles or flakes of blood pigment are occasionally found in the urine of menstruating females (Plate XIX., Fig. 5).

Pyelitis.

(Plate XXIII.)

The urine is generally increased in quantity, especially in chronic cases; it is turbid, generally pale, but not infrequently hæmorrhagic and then variously coloured; when pyelitis is not associated with chronic cystitis, the urine is almost invariably acid in reaction, and contains mucin in considerable quantity. The amount of albumen present is moderate, but greater than could be accounted for by the presence of pus-corpuscles.

Macroscopically, small and large concretions of uric acid may be seen. Microscopically, uric acid is found in spear-shaped and club-shaped crystals (Plate XXIX., Fig. 1; Plate XXIII., Fig. 3), along with calcium oxalate, numerous leucocytes arranged in groups or cast-like masses, red blood-corpuscles and epithelial cells derived from the renal pelvis and the collecting tubules. Renal casts are scarce, unless the kidney itself is affected.

Cystic Disease of the Kidney.

The cyst contents may be clear and watery, colloid or hæmorrhagic; they are always of low specific gravity, and generally contain urea; occasionally, however, urea is absent. Cellular elements may be completely absent from certain cysts; in others one may find a few leucocytes, epithelial cells, red blood-corpuscles, crystals of cholesterin and triple phosphate, as well as granular and fatty débris. The only characteristic feature observable in the fluid obtained by puncture is the presence

of dark brown rosette-like bodies of various sizes (or fragments of such), each having a structureless centre and from one to five concentric rings.

The urine is diminished in quantity; its specific gravity is low, 1009 to 1012; it is slightly albuminous, and contains but few formed constituents.

Hydronephrosis.

In addition to the local symptoms and the frequent variations in the quantity of urine, the micro-chemical characters of the hydronephrotic fluid often afford valuable aid to diagnosis. The fluid is clear and watery, or of a faint yellow colour; it generally contains albumen, and has a variable specific gravity. The demonstration of such urinary constituents as urea and uric acid, especially the former, is of great importance. Negative results, however, are of comparatively slight value, since these substances may be absent when the affected kidney is incapable of secretion.

Renal Abscess.

When a renal abscess ruptures, a variable amount of pus becomes mixed with the urine, which may contain, in addition, products due to the existence of parenchymatous nephritis, red blood-corpuscles, and, occasionally, fragments of renal tissue, which may be recognised by their structure. In suppurative nephritis of septic origin, bacteria casts may also be present in the urine.

The urine is turbid, generally ill-smelling, and of a yellowish or (when containing much pus) greenish-yellow colour. The amount of albumen present is not more than the pus can account for. The pus rapidly subsides and forms a dense yellowish-white or greyish-white sediment (resembling the earthy phosphates in colour).

Microscopic examination reveals the presence of numerous leucocytes, some of which appear normal, whilst others are in a condition of fatty degeneration. In the sediment the leucocytes form a dense greyish-white layer, under which the red blood-corpuscles, which are heavier, form a much thinner stratum.

When the pus is derived from some suppurative inflammation of the mucous membrane of the urinary passages, the microscopic characters are practically the same; in cases of renal abscess, however, the pus generally appears in the urine more suddenly, and its quantity is subject to considerable variations. The diagnosis as to which of the two kidneys is affected can, apart from local symptoms which are sometimes wanting, be made only by means of the cystoscope.

Renal Infarct.

(Plate XXVIII.)

The diagnosis of this condition is only possible by reference to concurrent symptoms or lesions, cardiac failure, endocarditis, pain and tenderness in the region of the kidneys, fever, hæmaturia, &c.

The characters of the urine or of the sediment (Plate XXVIII., Fig. 1) differ from those met with in hæmorrhagic nephritis, chiefly, by the greater abundance of leucocytes and scarcity of casts.

Congested Kidney.

[*Passive Renal Congestion; Renal Engorgement; Cardiac Kidney.*]

(Plates XXII. and XXIV.)

The following characters of the urine, although not pathognomonic of renal congestion alone, often afford good grounds for such a diagnosis. The urine is diminished in quantity, of high specific gravity, acid reaction, and dark in colour (owing to an increase in the urinary pigment). It contains albumen usually in moderate quantity, but not infrequently (specially when there is marked cardiac adynamia) in very considerable quantity. Urates are deposited generally abundantly, and form a reddish sediment.

Microscopic examination reveals, especially in severe cases, the presence of hyaline casts* which are particularly friable, cylindroids, epithelium (particularly from Bellini's tubes, but also from the bladder and other parts of the urinary passages), leucocytes, isolated red blood-corpuscles (specially when the congestion is intense or associated with nephritis), amorphous urates, and crystals of uric acid.

Acute Nephritis.

(Plates XXIII., XXV., XXVI., XXVII., and XXVIII.)

According as blood is present in, or absent from, the urine, acute nephritis may be termed hæmorrhagic or non-hæmorrhagic.

The presence of marked quantities of blood in the urine in a case of nephritis is, generally speaking, an indication of very acute inflammation; nevertheless, intercurrent hæmaturia may also occur in chronic nephritis, even in the "*true contracted kidney.*" The urine in acute nephritis is diminished in quantity (occasionally there is **Anuria**); it is acid in reaction, and generally of high specific gravity. Albumen is present, generally in considerable quantity, and may exceed 1 per cent.

The urine is turbid, owing to the presence of cellular elements; it is a yellow or dark brownish-red (when blood is abundant), or red (colour of meat juice). Clots are never present in the urine (a fact which serves to distinguish this condition from hæmorrhages from the lower urinary passages).

The sediment (which is generally very abundant) forms a loose flocculent deposit, and may contain uric acid, sodium and potassium urates, calcium oxalate, and (rarely) hæmatoidin. Most of the following cellular products are also usually present:—Red blood-corpuscles, generally decolourised or shrunken (isolated or in groups); leucocytes, epithelial cells from the kidneys and from the urinary passages; short narrow hyaline or pigmented casts (some of which are beset with red corpuscles, leucocytes, and renal epithelium, occasionally also with urate granules); blood casts are also found. In the later stages of the disease, in consequence of degenerations of the renal epithelium, true granular casts, fatty casts, waxy [colloid] casts, and, occasionally, genuine epithelial casts are present in the sediment.

The urine of acute nephritis may be distinguished from that of renal engorgement, by the large amount of albumen present, and also by the presence of blood and epithelial casts.

The condition of the urine (as regards quantity, specific gravity, &c.) does also, apart from the clinical history, help to decide whether a particular case is one of primary acute nephritis or an acute exacerbation of a chronic nephritis.

Chronic Parenchymatous Nephritis.

Inflammatory Fatty Kidney; [Third or degeneration Stage of Tubular, Catarrhal, or Desquamative Nephritis; Large White Kidney.]

(Plates X., XXIV., and XXIX.)

The urine is always diminished in quantity; it has a yellowish colour, and is frequently turbid owing to the deposition of organised products and urates. The specific gravity is high, varying, as a rule, from 1020 to 1040; the reaction is acid.

Albumen is present in large quantity, but is not so abundant as in acute nephritis. The urine deposits an abundant yellowish-white sediment. The casts are long and narrow, but become broader and shorter in later stages of the disease; hyaline casts are specially numerous, but finely- and coarsely-granular casts may also be present. In later stages bright wax-like [colloid] casts are found. Some of the casts may be covered with or contain fine fat globules (fatty casts) or epithelial cells, the majority of which are fatty. Free fat granule cells may also be found (Plate XXIX., Fig. 2) along with fine fat globules and fatty needles; the latter are either free or contained in cells (Plate XXXV., Fig. 1; Plate XXXIII., Fig. 2). Unaltered epithelial cells, especially from the kidney, and leucocytes may also be present; red blood corpuscles are either absent or extremely scanty.

* When the engorgement is complicated with nephritis, other varieties of casts are also present.

When chronic parenchymatous nephritis is associated with jaundice, the various cellular elements are stained by the bile pigments (Plate X., Fig. 6; and Plate XXIV., Figs. 3 and 4).

Chronic Hæmorrhagic Nephritis (*Weigert's Red or Mottled Kidney*).

(Plates XXX. and XXXI.)

This variety of chronic nephritis is of more frequent occurrence than the large white kidney. The kidneys are generally enlarged, but occasionally may be normal in size or less. The external surface and surface of section present a mottled appearance, owing to the alternation of areas of fatty degeneration with areas of hyperæmia or hæmorrhage.

The urine is acid, and, apart from quantity, which may amount to 1500 or 2000 c.cs. (although at times it is much less*), presents characters very similar to those in the contracted kidney; however, it frequently contains a considerable quantity of blood.

When the blood is absent or in very small quantity the urine is bright yellow, and contains albumen, but in smaller quantity than in acute nephritis. The sediment is scanty, pale yellow or reddish in colour (and presents the same characters as in the large white kidney, except that the number of red blood-corpuscles is generally larger); it contains hyaline and granular casts and also waxy [colloid] casts, especially in the fatal cases.

When blood is present in considerable quantity the urine is turbid, brownish-red or dirty brown, according to the amount of blood; on standing, it deposits an abundant sediment, and the supernatant fluid has then a meat juice colour; the quantity of the urine is diminished, as is also its specific gravity. The sediment contains numerous casts thickly coated with red blood-corpuscles (blood casts), and in fatal cases waxy [colloid] casts are also generally present; in addition there are red blood-corpuscles, most of them decolourised, leucocytes, numerous epithelial cells of renal origin, free and enclosed in casts, and fat granule cells as in the large white kidney.

During acute exacerbations the condition may be mistaken for acute hæmorrhagic nephritis; in the latter, however, the urine generally has a higher specific gravity, and contains a greater amount of albumen.

Secondary Contracted Kidney.

[*Contracting, Induration or Fourth Stage of Parenchymatous Nephritis; Chronic Indurative Nephritis; Small White or Contracted Kidney.*]

(Plates XXXII. and XXXIII.)

This condition occurs as a later stage of the large white kidney. It is characterised by the occurrence of, marked œdema differing in this from the primary contracted kidney. The urine may be normal in quantity, or, occasionally, somewhat increased; it has a bright yellow colour, is turbid and of low specific gravity (1008 to 1012). Albumen is fairly abundant (about 3 to 4 per mille). On standing the urine deposits an abundant greyish-white flocculent sediment, which consists, in great part, of granular debris (albuminous granules); it also contains many fatty cells (fat granule cells), fatty casts, hyaline casts or casts beset with fine granules and epithelial cells, and, occasionally, red and white blood-corpuscles (Plate XXXII., Figs. 1 and 2; Plate XXXIII., Fig. 2).

Genuine Contracted Kidney.

[*Chronic Interstitial Nephritis; Cirrhosis of the Kidney; Red Granular Kidney; Primary Contracted Kidney, &c.*]

(Plates XXII. and XXXIV.)

The urine is very considerably increased in quantity, sometimes amounting to 6000 or 8000 c.cs.; on the supervention of uræmia, and especially in the last stages of the disease, it is again diminished. It has a pale yellow colour and often a greenish hue; it is quite clear, slightly acid in reaction, and of

* This diminution is often associated with uræmia.

very low specific gravity, less than 1010, frequently 1005 (even in conditions of congestion and fever). The quantity of albumen is small, and at certain times of the day or night it may be absent, or, occasionally, it is absent for days or weeks together. The night urine has a lower specific gravity and contains less albumen than the day urine. The sediment is generally very scanty, greyish-white, finely granular, or, it may be altogether absent.

Microscopic examination of the sediment reveals the presence of a few long, narrow hyaline casts beset with a few fat globules, and (more rarely) broad granular casts (Plate XXII., Fig. 6). In cases of this disease due to lead poisoning, the sediment may also contain waxy [colloid] casts. Other cellular constituents are scanty, being found more especially during and after uræmic seizures; they comprise renal epithelial cells, most of them not degenerated and free, seldom forming casts; cells from the urinary passages; isolated leucocytes; rarely isolated red blood-corpuscles (especially during exacerbations); and, occasionally, crystals of uric acid and calcium oxalate.

This condition may be confused with amyloid degeneration of the kidneys.

Amyloid Degeneration of the Kidneys [*Lardaceous infiltration, Waxy Disease.*]

In this condition the characters of the urine are less distinctive than in the various forms of nephritis. Sometimes they resemble those found in connection with the large white kidney; at others those associated with the contracted kidney.

The urine is clear, pale yellow, generally normal in quantity, and of low specific gravity varying from 1010 to 1015. Albumen is present; sometimes in small, at others in considerable quantity.

The sediment is either absent or scanty; it contains various forms of casts, but especially pale, narrow hyaline casts, and occasionally waxy [colloid] casts.

The casts, when stained with methyl-violet by adding a solution of this dye to the urine, never give the amyloid reaction. The existence of some lesion capable of causing amyloid degeneration, and the absence of cardiac hypertrophy, indicate more clearly the probability of amyloid changes in the kidneys than the characters of the urine.

Tumours of the Kidney and Urinary Passages.

See pp. 68 and 74.

V. PREPARATION OF PERMANENT SPECIMENS OF URINARY SEDIMENTS.

The collecting of preserved microscopical preparations of urinary sediments is of little use, except for teaching purposes; but it may, occasionally, be desirable to preserve some unusual specimens, and the reader will probably expect to find some information on the subject in these pages.

With the object of providing the members of his classes of practical pathology with urinary sediments, retaining their natural appearances, the editor, in 1884, after many trials, adopted a certain number of methods. Several of these have yielded results so permanent that preparations which have now been kept twelve, fifteen, and even seventeen years are still in a state of good preservation.

These methods may, therefore, be safely recommended.

Generally speaking, the conditions essential to success are the following:—

1. The sediment must be completely separated from the urine, or, in other words, it must be thoroughly washed, otherwise the changes occurring in the urine would sooner or later cause precipitates, which would alter the characters of the deposit.

2. The fluids used for washing the sediments must be of such a nature that (*a*) they cause no permanent precipitate when added to the urine; (*b*) they do not dissolve (or combine with) the inorganic products which have to be preserved; (*c*) they fix the organised constituents without altering their size, form, and transparency (a slight discolouration may, however, be allowed and is even, at times, advantageous).

Preparation of Unorganised Sediments.

A short experience will convince anyone that it is almost impossible to find any watery solution which does not gradually act upon the unorganised sediments; even substances, such as uric acid, phosphate or oxalate of calcium, which seem almost insoluble, will gradually alter and undergo partial solution when kept in presence of an excess of water. This difficulty may be overcome by one of the following methods.

Dry Method.—This is probably the only method by which unorganised sediments can be preserved for any length of time without any marked alteration of their original appearances. The deposit is rapidly washed three or four times with distilled filtered water, and then dried rapidly at a temperature below 40° C. (When the product is insoluble in alcohol, the drying may be quickened by

washing with absolute alcohol.) The dust-like material thus obtained may be kept in perfectly dry air-tight tubes until required. The dry deposit may then be prepared for microscopical examination by mixing a little of it with a drop of water on a slide and covering it with a coverglass in the usual way.

Phosphates, carbonate of calcium, oxalate of calcium, urates, uric acid, cholesterin, cystin, hæmatoidin or bilirubin, and indigo may all be preserved in this way. (Thin crystalline plates, like those of cholesterin, may be mounted permanently in a dry cell and be suitable for microscopal examination; all the other crystals refract light too strongly when they are mounted in this way.)

Canada Balsam and Dammar Varnish Preparations. Several of the above products are either coloured or have an index of refraction differing considerably from that of Canada balsam or dammar varnish. This may be taken advantage of to make permanent microscopical preparations.

A little of the dry sediment, after being mixed with a small drop of water, is spread on the coverglass and then allowed to dry. *As soon as the drying is complete*, the coverglass is pressed gently, film downwards, upon a drop of Canada balsam or dammar varnish previously placed on the slide. Thick turpentine or xylol Canada balsam should be used for this purpose, or, better still, hard Canada balsam, softened by heating on the slide, just before the coverglass is placed on it.

In this way good preparations of *carbonate of calcium, urates, uric acid, tyrosin, Charcot's crystals, cystin, hæmatoidin, indigo*, &c., may be easily obtained.

In preparing the film, drying of the sediment should not be pushed too far; it is specially necessary to attend to this in the case of leucin, or else the crystals, spherules, or granules will become too transparent after a few days. Just enough water must be left in the crystals, &c., to prevent the balsam infiltrating them as long as it remains soft.

"Saturated Solutions" Method.—Oxalate of lime and phosphates become practically invisible when mounted in Canada balsam; on the contrary, when they are mounted in water, or alcohol, they are very distinct.

Water, or glycerine fluid (see p. 98), may be used as mounting media, provided these fluids have been previously saturated with the product which has to be preserved in them. This can be done by leaving a large excess of the sediment in contact with water or glycerine fluid for a few weeks before the fluid is used for mounting purposes.

Sulphate, urate, oxalate, and *phosphate of lime* should be mounted in cells filled with the "saturated" water or glycerine fluid. The cells * are made of shellac,

* A turntable is used to make round cells. A varnish ring of suitable depth is painted on the slide with a stiff brush, the size of the ring should be such that when the round coverglass is placed over the cell, one-half of the thickness of the varnish ring is outside the edge of the cover. The varnish being allowed to dry until it is just soft enough to be indented when the coverglass is pressed against it, a large drop of the mounting fluid is placed within the ring, the sediment well mixed with the fluid, a coverglass is then placed over the cell and pressed gently until its edges are firmly fixed by the varnish; the fluid which has escaped is then removed, the coverglass and varnish well washed with water and allowed to dry. Another ring of varnish is then painted over the edge of the cover to completely seal the cell.

sealing wax, gutta-percha, varnish, or any other substance which does not harden rapidly, and is not acted upon by water or glycerine fluid.

The *ammonio-magnesian phosphate* is best preserved in a *solution of ammonia*, but as ammonia rapidly attacks most varnishes, evaporation takes place more or less rapidly, and it is usually difficult to preserve mounted preparations of this sediment for more than two or three years.

Glycerine jelly may be used to preserve many sediments, but the preparations are seldom durable; occasionally, however, good permanent specimens may be obtained.

Preparation of Organised Sediments.

Fixing* and Mounting Fluids.—The solutions used for washing these sediments must be capable of fixing the cells and cellular products in the state in which they are found in fresh urine.

After the sediment has separated slowly in a sedimentation glass, or been separated rapidly by centrifugalisation, the supernatant fluid is decanted or syphoned off as completely as possible.

Then 5 to 10 parts of one of the following fluids are added to the sediment:—

A. *Müller's Fluid*,† diluted with an equal part of water or *bichromate of potash* (1 per cent. solution).

B. *Dilute Alcohol* (30 per cent. to 50 per cent.).

C. *Glycerine Fluid*.‡—For the purpose of preserving blood-corpuscles and tube casts, $\frac{1}{8}$ per cent. to $\frac{1}{4}$ per cent. of *perosmic acid* may be added to this fluid just before use. (Phenol should not be added to glycerine fluid intended for use with osmic acid.)

D. *Formal Solution* (2 per cent.—*i.e.*, 2 parts of the commercial solution of formaldehyde to 100 parts of water).—This solution seems to be the best for general use, but has not been tried sufficiently long to make its superiority over the other solutions a matter of certainty.

As soon as the sediment has separated from the mixture, the supernatant fluid is decanted and replaced by the same amount of fresh solution. After this process has been repeated two or three times, the deposit is treated in various ways according to the nature of the solution.

A. *Müller's Fluid or Bichromate of Potash Preparations.*

The diluted fluid is replaced by undiluted Müller's solution or 2 per cent. bichromate of potash. The sediment is then left in this fluid for two or three weeks, after which it is separated and washed thoroughly with 50 per cent. alcohol. The alcohol is then replaced by glycerine fluid. The sediment may then be kept in well-stoppered tubes for many years, provided the amount of glycerine fluid be

* The word fixing is used here not exactly in the same way as it is in ordinary histological works, the term hardening would not, either, be quite appropriate.

† Bichromate of potash, 2 parts; sulphate of soda, 1 part; water, 100 parts.

‡ Alcohol, 10 parts; glycerine, 10 parts; water, 10 parts; phenol, 1 part.

small, in fact just large enough to keep the material in a moist state. A small quantity of the prepared sediment may then be mixed gently on the slide with a drop of Farrant's medium, or with glycerine fluid, and mounted in the usual way. All *organised sediments* and more specially *tube casts* may be prepared in this way; the only change observable, after a time, is a slight green discolouration, which is not without advantages, and does not materially alter the most important features of cells or cellular products.

B. *Dilute Alcohol Preparations.*

After the first washings the alcohol is replaced by glycerine fluid, and may then be mounted permanently at once.

C. *Glycerine Fluid Preparations.*

After four or five washings of the original sediment, preparations may be mounted permanently in the same fluid; this method and the precedent give good results, but the cells and tube casts have a tendency to be too transparent, and the tube casts are not so permanent as when Muller's fluid has been used. *Red blood-corpuscles* swell and become less distinct. This method is specially suitable for *epithelial cells, shreds of tissue,* and *pus. Uric acid, oxalate of lime,* and *phosphate of lime* may occasionally remain long unaffected after this treatment, when they are abundant in the sediment.

C′. *Glycerine Fluid with Osmic Acid.*

After the first two or three washings, this fluid is replaced by ordinary glycerine fluid. The sediment may be mounted either in glycerine fluid or in Farrant's solution. This method is suitable for *all organised sediments,* and *specially tube casts and blood-corpuscles.* A marked olive-brown colour is observed in all cases, and occasionally the cells and tube casts become coarsely granular.

D. *Formal Preparations.*

After one or two washings, the formal solution is replaced by dilute alcohol, and ultimately by glycerine fluid.

If, for special purposes, some of the products have to be stained with hæmatin, carmine, picrocarmine, or any of the aniline dyes, this can be done by using dilute solutions of the stains in the same way as the hardening solutions, the excess of stain being removed also by the washing method.

It is almost needless to say that all the manipulations described above must be conducted with great care, so as to avoid the breaking or crushing of such delicate structures as tube casts.]

VI. BIBLIOGRAPHY.

Beale, Lionel S. (London). Kidney Diseases, Urinary Deposits, and Calculous Disorders. London, 1869.

Beaunis, H. (Paris). Nouveaux elements de Physiologie humaine. Paris, 1888.

Bird, Golding (London). Urinary Deposits. London, 1857.

Bizzozero, G. (Turin), and **C. Firket** (Liége). Manuel de Microscopie Clinique. Bruxelles, 1888.

Bunge, G. (Bale). Text-book of Physiological and Pathological Chemistry. Translated by **L. C. Wooldridge.** London, 1890.

Bury, Judson S. (Manchester). Clinical Medicine. London, 1894.

Cornil and **Ranvier** (Paris). Manuel d'Histologie Pathologique. 2nd Edition. Paris, 1882.

Dickinson, W. H. D. (London). On Renal and Urinary Affections. London, 1885.

Flügge, C. (Breslau). Die Micro-organismen. Leipzig, 1896.

Funcke, O. (Leipzig). Atlas of Physiological Chemistry. London, 1853.

Halliburton, W. D. (London). A Text-book of Chemical Physiology and Pathology. London, 1891.

Hamilton, D. J. (Aberdeen). A Text-book of Pathology. London, 1894.

Jakseh, R. v. (Prague). Clinical Diagnosis (Prague). Translation by **James Cagney.** 4th English Edition edited by R. v. Jaksch. London, 1899.

Landois, L. (Greiswald) and **Wm. Stirling** (Manchester). A Text-book of Human Physiology. London, 1891.

Macé, E. (Nancy). Traité pratique de Bacteriologie. Paris, 1897.

Mann, J. Dixon (Manchester). Forensic Medicine and Toxicology. London, 1899.*

Muir, R. (Glasgow), and **J. Ritchie** (Oxford). Mannal of Bacteriology. Edinburgh and London, 1897.

Neubauer, G., and **J. Vogel** (Wiesbaden). On the Urine. Translated by **W. O. Markham.** London, 1863.

Ralfo, C. H. (London). Clinical Chemistry. London, 1883.

Roberts, Sir William (Manchester). On the History of Uric Acid in the Urine. *Proc. Med. Chir. Soc.* London, 1890.

* To be consulted on Toxicological and Medico-legal questions relating to the urine.

Robin, C. (Paris). Leçons sur les humeurs normales et morbides. Paris, 1867.

Salkowski (Berlin) and **Leube.** Die Lehre vom Harn. Berlin, 1882.

Schafer, E. A. (London). Text-book of Physiology. London, 1898.

Sherrington, C. S. (Liverpool). Experiments on the Escape of Bacteria with the Secretions. *Journ. of Pathology and Bacteriology*, vol. i., p. 258. Edinburgh and London, 1893.

Simon, C. E. (Baltimore). A Manual of Clinical Diagnosis. Baltimore, 1896.

Slater, C., and **J. Spitta** (London). An Atlas of Bacteriology. London, 1898.

Stewart, Sir T. Grainger (Edinburgh). A Practical Treatise on Bright's Diseases of the Kidney. 2nd Edition. Edinburgh, 1871. Also Edinburgh Hosp. Reports, vol. i., 1893.

Ultzmann, R., and **K. B. Hofmann** (Vienna). Atlas der physiologischen und pathologischen Harnsedimente. Vienna, 1872.

Woodhead, G. Sims (Cambridge). Practical Pathology. 3rd Edition. London, 1892.

Ziegler, E. (Freiburg). A Text-Book of Special Pathological Anatomy. Translated and edited by **Donald MacAlister** and **H. W. Cattell.** London and New York, 1896-98.

A great number of small manuals and original articles have also been consulted, but as sufficient reference to them will be found in the works quoted in the above list, it has not been thought necessary to give a more extended bibliography.

VII. INDEX OF AUTHORS

(Quoted in the Text).

N.B.—For Authors of Treatises or General Articles, see *Bibliography.*

VIII. INDEX OF SUBJECTS.

Note.—The heavy figures indicate the pages on which the description, general occurrence, differentiation, reaction, and reference to the plates for each substance are given.

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BELL AND BAIN, LIMITED, PRINTERS, GLASGOW.

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